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ABSTRACT

This volume is a report of the development of the first course in a two-semester sequence in Electronic Communications, for a new degree program in Electric Engineering Technology at Valencia Community College, Orlando, Florida. Evolution of the program is described with comments relating the philosophy and importance of a communications sequence. The bulk of documented material consists of a detailed course description, of laboratory procedures and examinations. Supplementary notes for student reference are included. This material may be utilized directly or as a guide by an instructor assigned responsibility for conduct of a communications course. This report concludes with recommendations for utilization and improvement of the material and includes comments relevant to integration with related advanced courses. (Author/HM)

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ED175654

Development and Integration

Of

A COURSE IN ELECTRONIC COMMUNICATIONS

For

A New Engineering Technology Program

At

Valencia Community College

by

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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I. INTRODUCTION

Valencia Community College initiated an AS degree program in Electromechanical Technology in the fall of 1972. The program was expected, by the administration, to be well received since it intended to orient the student toward electronics as well as mechanical or electromechanical employment potential. The program was begun using part-time instructors. The following year a full time instructor was appointed to coordinate the gradually enlarging number of students and to permit day classes to be offered.

As time passed and experience with student registration was gained, it became evident that the majority of students were not interested in the mechanical aspects and courses of the program. They were willing to register for the electronics courses but were ignoring, for the most part, those courses which were mechanically oriented. The courses would seldom register sufficient students to justify making the offering a class reality. This reaction has occurred at other schools offering such programs. Students appear to be interested in pursuing either electronics and electricity or mechanically oriented technology, but not both. (There are, of course, exceptions to test the rule). Similarly, employers have appeared to desire more thorough training than can be obtained when the concentration is diluted into two areas.

Therefore, during the spring of 1974, as a result of experience and survey, it was decided that an additional, more specialized, AS degree program should be offered, i.e. one in Electronics Engineering Technology. The program in Electromechanical would be retained for the benefit of those already well committed and for the few students who might, in the future, find such a program attractive. Thus, it would be necessary that a maximum number of courses be applicable to either the Electronics or Electromechanical programs with

certain new courses to provide for the alternative specialization in Electronics. The development of the additional new courses would involve particular attention to insure that they integrate properly with the dual applicability of prerequisites.

It was also considered that the new program for Electronics offered the opportunity to create a high quality program which would be attractive to students and recognized by industry. It need not be a mere rehash of courses and format offered by other schools. Thus, for example, it evolved that among the new courses required, would be a second year, two semester sequence in Electronic Communications, and a two semester sequence in Semiconductor Circuits. Previous programs at other schools have typically offered these subjects as a one semester course with a consequent "survey" or "broad brush" approach. The writer was designated to develop the Communication courses, because of related industry background and teaching experience in similar courses.

EL 208, Electronics Communication I was offered for the first time, with the writer instructing, in Term II commencing January, 1975. This report describes the procedures, results, and material developed for the first course of the communications sequence.

II. BACKGROUND AND SIGNIFICANCE

A. THE ELECTRONICS TECHNICIAN

The objective of the total curriculum in Electronics Engineering Technology is to produce a competent electronic technician. The technician must be capable of working and communicating directly with engineers, scientists, and production personnel in his specialized work; of satisfactorily performing and producing for his employer, and of growing into positions of increasing responsibility. A curriculum to produce this type of graduate, must be carefully designed. Each course must be planned to develop the student's knowledge and skills in a particular area and must be directly integrated into the overall curriculum. Each course should contribute uniquely in the sequence of courses which is planned to progress toward the final objective of producing a competent technician.

Graduates of an Electronics Engineering Technology program are expected to find employment opportunities in many areas of the electronics field. Each area may require somewhat different specialized knowledge and skills. The following listing has often been used to describe some of the major areas or clusters of job opportunities as described by employers.[1]

(1) Research and Development Technician: The technician working directly with engineers and scientists in developing new devices or doing basic research.

(2) Sales and Service Technician: A technician representing a company and its products to a customer. He advises the customer and is capable of installing, operating, trouble shooting, and training the customer's personnel to service and maintain equipment located at the customer's installation.

[1] U.S. Dept. of Health Education and Welfare. Office of Education, Electronic Technology, A suggested 2 Year Post High School Curriculum U.S. Government Printing Office 1969.

(3) Operations Technician: The technician working in a manufacturing facility that maintains automated equipment; checking and calibrating measuring equipment; fabricating special apparatus for use in the manufacturing plant; checking and troubleshooting electronic control devices and systems; and training skilled plant workers in the operation of electronically controlled equipment.

(4) Communications Technician: A technician working in broadcast and television installations, microwave networks, or mobile two way communications systems. (Many such positions require that the technician hold a valid license issued by the Federal government. Such licenses are based upon examination conducted by the Federal Communications Commission. A course in communications is therefore of additional significance.)

In addition to these four major areas, there are numerous other areas in which they may work. A few additional examples will further indicate the wide diversity of employment opportunities often found by well qualified graduates.

(1) Nuclear instrumentation

(2) Electronic components

(3) Product test and evaluation

(4) Quality control

(5) Biomedical Electronics

(6) Telemetry

(7) Oceanography and marine research

(8) Automotive electronics

Because electronic technicians may be employed in such a diversity of broad but often specialized areas, the adequately trained technician must have attained certain abilities, scientific knowledge, and technical skills. These have been very generally defined as follows:[2]

(1) Mathematical facility; i.e. the ability to use algebra and trigonometry as tools in the development of ideas and plans. An understanding, although not necessarily proficiency of some higher mathematics according to the requirements of the technology.

[2]U.S. Dept. of Health Education & Welfare, Office of Education, Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs U.S. Government Printing Office 1962.

(2) Proficiency in the application of physical principles, including the basic concepts and laws of physics and chemistry that are pertinent.

(3) An understanding of materials and processes.

(4) Knowledge of a field of specialization.

It might be anticipated that to prepare a graduate for the range of job opportunities and their related knowledge requirements would be a formidable task. For a two year curriculum to respond to such a demand necessitates emphasis on two important aspects of learning:

(1) Specific knowledge with heavy emphasis upon fundamental principles.

(2) Acquisition of a viewpoint and attitude (concerning technical subjects or problems).

The sequence of courses in the two year technical curriculum is as important as the content of the courses if the limited time available is to be effective. In general, the subject matter of the curriculum must be coordinated in groups of concurrent courses which are, hopefully, arranged to blend smoothly from one group of courses to the next, thus carrying the student to a deeper understanding of basic principles while broadening his scope of understanding. This may be in sharp contrast to the arrangement of a professional curriculum in which basic and somewhat unrelated courses make up the first part of the study program and specialization is defered to subsequent terms.

Thus, the sequence in Communications, is very important. In a well integrated curriculum in Electronics Engineering Technology, a Communications course is typically, the first real introduction to the interrelationships of principles and the important "systems" viewpoint. Up until this time, the student has had presented to him and has been preoccupied with fundamental principles of electronic components and their connection into basic circuits. The transition into systems, for many students, is often difficult because of

the multiple interactions which occur among the elements of even the most simple system. Fortunately, many of these interactions, in a communication system, have been observed by the average student. Although, the system may not have been consiously analyzed, there is at least a partial intuitive understanding acquired through experience with radio, television and fundamental everyday acts of communicating. The course in electronic communications thus marks a transition between the rather narrow circuits analysis approach of prior courses and the justification for their existence, i.e. their use in systems.

B. THE COMMUNICATION SYSTEM

The term communication, as used in "Electronic" Communications, is defined as the process whereby information is transferred from one point in space (or time, for that matter) to another point, a receiver. Since there are many philosophical implications to the term, it might be well to comment briefly upon the idea of information. For our purposes, information is though of in a physical sense i.e. a message. Whether or not the message is useful, redundant or efficient involves considerations which are very important and interesting. However, information theory is another subject in itself and such additional meanings need not prevent us from proceeding with a conceptual understanding of communications. Our concern is with the message, regardless of its type and with communications systems as a means of transmitting a message from source to destination so that the received message is an acceptable replica.

Functionally, a communication system may be diagrammed as shown by Figure 1. (Also shown are some of the unwanted elements which are inevitably present such as noise interference, etc.) It is seen that in addition to transducers, there are three essential parts to an electrical communications system, transmitter, transmission medium, and receiver. Each has a particular function.

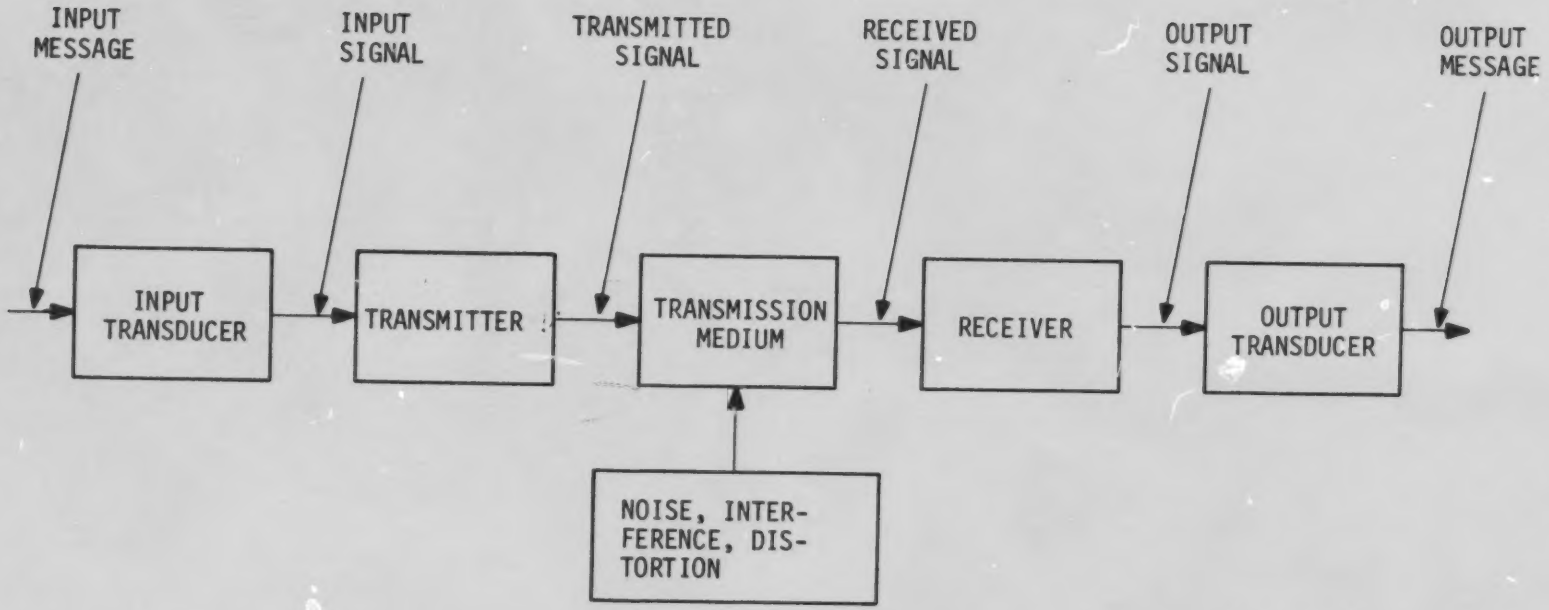


Figure 1. Elements of the Communication System

A. Transmitter

The transmitter converts the message into a form which is compatible with the transmission medium. Several processing operations may be necessary such as amplification, coding or translation. The commonest and most important of these operations is modulation. Modulation is the process which will allow coupling and matching of the message to the properties of the medium through the use of a carrier.

The items of hardware which typically make up a transmitter include the modulator and carrier circuitry, filters, amplifiers, and the transmitting antenna or equivalent coupling device.

B. Transmission Medium

The transmission medium is sometimes called the channel. It is the electrical connection between transmitter and receiver, serving to bridge the distance from source to destination. It may be a pair of wires (transmission line), a coaxial cable or waveguide, or a radiating electromagnetic wave such as radio waves or laser beams.

C. The Receiver

The function of the receiver is to extract the desired signal from the transmission medium and deliver it to the output transducer. Since the received signal may be weak as a result of attenuation through the medium, there may be several stages of amplification. However, the key operation performed by the receiver is demodulation, (often called detection), which is the reverse of the transmitters modulation process, thus restoring the signal to a replica of its original form.

The components of a typical receiver include the antenna or coupling device, tuning circuits and filters, demodulator(s) and amplifiers.

In any practical communication system a source can be identified that generates the message, a destination that receives it, and a channel which transmits it. The source can be described in terms of the properties of the messages it can generate, the destination in terms of the properties of the messages acceptable to it, and the channel in terms of tne properties of the signals it can accept and deliver. Transducers are required between the source and channel if there respective properties are incompatible and similarly netween channel and destination. For example: the microphone at the transmitting end or a loudspeaker at the receiver.

For a communication system to be of value, at least part of the information contained in the original message must be received at the destination. However, it may be altered in one or more ways. It may be changed in form, added to, subtracted from or delayed in time with respect to the original message.

C. THE COMMUNICATIONS COURSE AS AN INTRODUCTION TO SYSTEMS TECHNOLOGY

The acceleration in growth and complexity of technology and the resultant recognition of multiple interactions among elements of even the most simple systems, justifies increased emphasis on the systems viewpoint and the concept of systems engineering or systems technology. Systems engineering has as a primary function the requirement that all elements of a system be considered in terms of their basic limitations, their interactions and possible alternatives. To perform this function properly requires a broad insight and conceptual understanding.[3] Intuitive reasoning often is of great importance since factual information may not always be available concerning interactions of the multiple elements. Basic limitations however, can not be ignored. Engineering catastrophes have occurred in sophisticated projects simply because elementary

[3]Arthur Hall, A Methodology for Systems Engineering, Princeton, N.J., 1965

details or interactions did not receive sufficient attention. For example an advanced missile test firing did not proceed on schedule because Ohm's law and its effect on a remote firing circuit had been overlooked.

Any system inherently represents two fundamental types of problems or limitations; those of technology and those of physics. The technological problems are those that can be solved, in theory at least, while the fundamental physical limitations offer no recourse even in theory. A problem, inherent to both, is the difficulty sometimes involved in recognizing and separating them. The problems of technology include equipment availability, economics, and choice of techniques or resources. Physical limitations, however, dictate what can or cannot be accomplished. Complex machinery can be devised to perform many tasks do not include those of paradox. Perpetual motion devices have met with little success.

Unfortunately, the engineering or technology student often finds himself so rapidly absorbed in mathematical tools and the necessity to solve detailed classroom type problems, that he may have restricted the range of his conceptual understanding. Yet, separation and identification of constraints - the formulation of the true problem - may be more important than any other task. A course in electronic communications thus offers a useful opportunity to acquire knowledge of a specialized area but, equally important, to develop a systems viewpoint.

A communications technician can often perform creditably if he has developed intuitive reasoning and conceptual understanding derived from analogy and experience despite a possible lack of proficiency (or inclination) for mathematics or probability theory. Concepts can often be discussed in terms of analogy rather than mathematics. Since a conceptual understanding is of prime

importance, presented material can be more representative than exhaustive or rigorous. For the technology student, an introduction to communications, and systems in general, can be an important step. The principles and logic involved in the communications process are often basic to other areas of engineering. A conceptual understanding and the viewpoint developed may have carry over into many fields such as data processing, control systems, computers and even systems not yet developed.

III. PROCEDURE

The objective of efforts for this report was to develop the first course in a two semester sequence in Electronic Communications for Valencia Community College. The course, designated as EL 208, Electronic Communications I is a four credit course with 3 hours lecture and 3 hours laboratory per week. The development consisted of specification of text and development of class and lab materials. Included are the course outline, class projects and assignments, progress tests, laboratory experiments and specification of laboratory equipment.

A summary of steps in the procedure follows:

1. An examination of the overall curriculum in Electronics was undertaken in order to insure that the new course would integrate properly with prerequisites and corequisites as has already been discussed. It was also necessary to consider that there would be a few students registered in this course without interest or background for the AS degree.

2. Courses offered at other Community Colleges in similar programs were examined as an aid to establishing the level and pace of the material. Catalogs which were examined for their course descriptions included those of Daytona Beach Community College, Florida A&M, Norwalk Technical Institute, The Penn State University (two year programs), Seminole Junior College, and Southern Technical Institute. (The writer has had direct experience or contact with these schools.) The model program envisioned by the U.S. Dept. of Health, Education and Welfare in their Technical Education series for Electronics Technology was especially helpful.

3. Available textbooks in this subject area at the two year level were reviewed. The 8 texts reviewed are listed in the bibliography. The text selected was George Angerbauer's, "Electronics for Modern Communications." Prentice Hall 1974.

4. Industry and advisory board, associates were consulted for their attitudes regarding required knowledge and skills.

5. A course outline was prepared and topics selected for laboratory experiments and projects.

6. Material was scheduled and textbook references determined.

7. Lesson plans with units of instruction were drafted.

8. Suppliers of laboratory equipment were surveyed to determined availability of developed training hardware. At the time of course initiation it was determined that no new equipment could be acquired for the "new" course first offerings.

9. Procedures for laboratory experiments were prepared. The relationship between laboratory time and class lecture is of great importance in a technology program. The theory, skills, techniques principles, materials, knowledge, processes, and understainging needed by the technician could probably be taught in the laboratory without separate and orgainized theoretical classes. However, the converse is not true. Skills knowledge, and capabilities required as the most important attributes of a technician cannot be learned in classrooms without related laboratory experimentation and experience. Thus, the inclusion and coordination of lecture sessions with appropriate laboratory topics is very important. Obviously, it is not possible to supply all experiences which a technician will potentially need in his future employment. However, it is reasonable that the student will have acquired basic skills and experiences enabling him to profit effectively from his expected on-the job training and assignments.

For this introductory course in communications, certain compromises in experiments were necessary, due to the immediate unavailability of specialized

training hardware. All of the experiment procedures which were written, were predicated upon the availability of existing electronic lab components and test equipment. Future offerings of the course may profit from greater use of specifically designed "training" hardware.

10. Progress tests and a final examination were developed.

11. The course was conducted, with the first class of students. The course began January 7, 1975 and concluded April 17, 1975. There were 15 students registered. Format, content and the lab experiments were revised as the class proceeded. Conduct of the class with actual students provided essential information for revision of scope and depth of material. The lab experiments were examined, as they were used, for their realism and achievability. Revisions were incorporated.

12. Upon completion of the first semester class, the material was thoroughly reexamined and updated to incorporate missing elements and to correct apparent deficiencies.

13. Results were reviewed with peer instructors and industry associates. Further modifications were incorporated.

The course material as revised follows:

IV. RESULTS

A. COURSE DESCRIPTION AND OBJECTIVES

(EL 208)

ELECTRONIC COMMUNICATIONS I

This course continues and expands the study of electronic circuits begun in previous courses and introduces circuits of fundamental importance to electronic communication systems. Because of the scope and complexity of the techniques and equipment involved in modern communications, this course is the introduction to principles and interrelationships of a broad range of communication components and circuits. Although not specifically directed toward Federal Communications Commission (FCC) license requirements, the course material and format is organized such that preparation for the federal examination may be completed if supplemented by student study of legal and operational portions of the exam. The textbook selected contains all necessary information for the student having this objective. Students should be encouraged to obtain an FCC commercial license since it is a requirement for employment in many areas of the electronic industry.

Included in the course is a review of relevent fundamentals followed by topics including communication system requirements, techniques of modulation and demodulation, principles of transmitters and receivers, oscillators, tuned amplifiers, antennas and other communication components. Principles of vacuum tubes are reviewed briefly since the maintenance technician may encounter equipment which was designed in prior years when vacuum tube technology was prevalent.

Laboratory work parallels topics of the lecture sessions and provides experience in connecting and testing component circuits and in using them in conjunction with other components.

	Major Divisions	Class Hours	Laboratory Hours
I.	Introduction to Communication Systems	2	o
II.	Review of Alternating Current, Inductance, Capacitance, Complex Circuits	6	6
III.	Resonant Circuits	1	3
IV.	Vacuum Tube Fundamentals	2	1
V.	Audio Amplifiers	2	2
VI.	Radio Frequency Amplifiers	3	3
VII.	Oscillators	3	5
VIII.	Basic Transmitters	3	5
IX.	Modulation Techniques	5	6
X.	Principles of Receivers	5	6
XI.	Antennas	3	0
XII.	Transducers	3	3
XIII.	Principles of Television	6	0

Course Objectives:

This introductory course in Electronic Communications is intended to bridge the gap between isolated circuits and components already studied and their utilization and interrelationships in systems. The student registered in this course should accomplish the following:

(1) Learn the vocabulary of a broad range of communication components and system elements.

(2) Understand the input-output relationships of communication components and circuits.

(3) Understand the use and interactions of communication system components when utilized for their system function.

(4) Become prepared to understand and pursue a more mathematical analysis of communication system behavior.

(5) Acquire a viewpoint conducive to consideration of technical problems from the "big picture" i.e. systems approach.

(6) Obtain sufficient knowledge of electronic communications practice enabling further self-study to result in passing the Federal Communications Commission Commercial License examination.

B. COURSE SCHEDULE AND TEXT REFERENCES

EL 208

ELECTRONIC COMMUNICATIONS I

TEXT: Electronics for Modern Communications by George Angerbauer
Prentice Hall 1974

Week	Topic	Text
1	Introduction to Communication Systems	Notes
	Review of Alternating Current	Chapt. 4
	Inductance and Transformers	Chapt. 5
2	Capacitance	Chapt. 6
	A-C Circuits	Chapt. 7
3	Resonant Circuits	Chapt. 8
	Vacuum Tube Fundamentals	Chapt. 11
4	Progress Test No. 1	
	Audio Amplifiers	Chapt. 13
5	R-F Amplifiers	Chapt. 14
6	Oscillators	Chapt. 16
7	Basic Transmitters	Chapt. 17
8	Progress Test No. 2	
	Modulation Techniques	Chapt. 18
9	Frequency Modulation	Chapt. 19
10	Receivers	Chapt. 21
11	Antennas	Chapt. 20
12	Microphones and Loudspeakers	Chapt. 27
13	Progress Test No. 3	
	Television	Chapt. 23
14	Television	Chapt. 23
15	Review	
	FINAL EXAM	

C. MAJOR DIVISIONS AND UNITS OF INSTRUCTION

EL 208

ELECTRONIC COMMUNICATIONS I

I. Introduction to Communications

A. Units of Instruction

1. Information
2. Transmitter
3. Channel
4. Receiver
5. Modulation and Demodulation
6. Bandwidth

II. Review of Alternating Current, Inductance, Capacitance, Complex Circuits

A. Units of Instruction

1. Waveshapes
2. Instantaneous, Peak, Average, and Effective Values
3. Frequency and Phase
4. Inductance and Mutual Inductance
5. RL and RC Time Constants
6. Transformer; Turns Ratio, Impedance Matching
7. Audio Frequency and Radio Frequency Transformers

B. Laboratory Project(s)

Construct and test circuits demonstrating impedance and phase relationships, and impedance matching, by use of transformer.

III. Resonant Circuits

A. Units of Instruction

1. Resonance
2. Series Resonant Circuits
3. Parallel Resonant Circuits
4. Circuit Q
5. Bandwidth
6. Low and High Pass Filters
7. Band Rejection and Bandpass Filters

B. Laboratory Projects

Predict and experimentally verify the resonant frequency, Q and bandwidth of a resonant circuit

IV. Vacuum Tube Fundamentals

A. Units of Instruction

1. Triode
2. Parameters, mu, gm, tp
3. Tetrodes
4. Pentodes

B. Laboratory Project: Examine vacuum tube construction and identify component parts

V. Audio Amplifiers

A. Units of Instruction

1. Class A, AB, B, and C amplifiers
2. Biasing
3. Coupling Methods
4. Gain and Distortion

5. Paraphase, Push-Pull Operation

6. Inverse Feedback

7. Cathode, Emitter, Source Followers

B. Laboratory Project:

Construct, test and demonstrate principles of Class A and Class B push-pull amplifier

VI. Radio Frequency Amplifiers

A. Units of Instruction

1. Use of Resonant Circuits

2. Class C Operation

3. Series and Shunt Feed

4. Interstage Coupling

5. Neutralization

6. Frequency Multiplication

7. Power and Efficiency

B. Laboratory Project

Construct and test R.F. amplifier to demonstrate Class C operation, series or shunt feed, and frequency multiplication

VII. Oscillators

A. Units of Instruction

1. Requirements for Oscillation

2. Types of Oscillators; Armstrong, TPTG, Hartley,

3. Colpitts, Pierce, Clapp, ECO,

4. Crystal Controlled Oscillators.

5. Crystal Characteristics

6. Other Oscillators; Phase shift, high frequency,

7. Dynatron, Tunnel Diode, Unijunction, Multivibrators

8. Parasitics.

B. Laboratory Projects

Construct and test LC oscillator.

Construct and test crystal oscillator.

Construct and test R-C phase shift oscillator.

VIII. Basic Transmitters

A. Units of Instruction:

1. Fundamental concepts

2. Single stage, MOPA, frequency conversion

3. Power Amplifiers,

4. Keying methods

5. Tuning

6. Harmonic radiation

B. Laboratory Project

Construct and test model MOPA transmitter

IX. Modulation

A. Units of Instruction

1. Basic concepts

2. Amplitude modulation

3. Basic Modulation systems

4. Sidebands and modulation percentage

5. AM methods

6. Power, voltage current relationships

7. Principles of double and single sideband modulation

8. Frequency Modulation fundamentals

9. Modulation index and Percentage modulation

10. Sidebands and Bandwidth

11. Preemphasis and Deemphasis

12. FM methods

B. Laboratory Project

Construct and test circuits to demonstrate principles of modulation.

X. Receiver Principles

A. Units of Instruction

1. Basic Functions

2. Types of Receivers; TRF, Regenerative,

3. Superregenerative, Superheterodyne, Diversity

4. Demodulators (detectors) for AM

5. Mixers and converters

6. Image frequency, selectivity

7. Automatic volume control

8. BFO

9. Noise limiters and squelch circuits

10. FM demodulators

B. Laboratory Projects

Construct and test circuits demonstrating frequency conversion and demodulation

XI. Antennas

A. Units of Instruction

1. Function of antenna

2. Radiation

3. Ground waves, sky waves

4. Transmission lines

5. Types of Antennae; Hertz, Marconi, Counterpoise,

6. Long-wire, Folded Dipoles, Directional Arrays,

7. Loop antennas

8. Polarization

9. Radiation patterns.

10. Power and Gain

XII. Transducers

A. Units of Instruction

1. Microphones: single and double button

2. Carbon, dynamic, crystal, condenser

3. Loudspeakers, magnetic, dynamic, capacitor

4. Earphones

5. Logarithms

6. Bels and decibels

7. Other transducers; input-output devices.

B. Laboratory Projects

a. Test and demonstrate microphones and loudspeakers.

b. Predict and verify decibel measurement.

XIII. Television Principles

A. Units of Instruction

1. Scanning

2. The CRT; deflection and focusing

3. Camera's; iconoscope, image orthicon, vidicon

4. NTSC television system

5. Blanking, synchronizing and equalizing pulses
6. The complex video signal: Video modulation
7. Video and Aural transmitters
8. Vestigial sideband transmission: Power and bandwidth
9. Receiver requirements: video detection, deflection circuits.
10. Color Television fundamentals

D. PROCEDURES FOR LABORATORY EXPERIMENTS

EXP. NO. 1

EL 208

ELECTRONIC COMMUNICATIONS I

Impedance Matching

PROCEDURE:

1. Determine turns ratio of lab transformer by checking voltage transformation in both step up and step down conditions. Use Laboratory signal generator as source of 1500 Hz. sine wave alternating current for input to transformers, and oscilloscope for voltage measurements.

   a. Transformer Identification _____ _____
   b. Step up connection.
      V_{pri} _____ _____
      $V_{sec.}$ _____ _____
      Ratio _____ _____
   c. Step down connection:
      V_{pri} _____ _____
      V_{sec} _____ _____
      Ratio _____ _____

2. Determine Thevenin equivalent source impedance of Lab signal generator while supplying 3 volts p-p sine wave at 1500 Hz. This can be accomplished by first measuring output voltage for no load and then applying resistive load and adjusting load so that output voltage is exactly one half its unloaded value.

   Signal Generator Z_{TH} _____

3. Connect sufficient resistance in series with signal generator output so that 1000 ohm generator impedance is obtained.

   R_S _____

4. Calculate resistance required as transformer load (using transformer in step down condition) in order to "match" the 1000 ohm source impedance of signal generator.

   R_1 _____ _____

5. Connect step down transformer to 1000 ohm signal generator operating at 500 Hz, supplying 3 V p-p, and experimentally determine load resistor required to obtain matched condition.

   R_L _____ _____

   Does value obtained agree with calculated value? Explain.

6. Determine frequency range over which matched condition is maintained within ±10%.

   F_{min} _____ _____
   F_{max} _____ _____

7. Experiment is to be repeated using different transformer

8. Discuss results and conclusions. Be concise.

EXP. NO. 2

EL 208
ELECTRONIC COMMUNICATIONS I

Inductance, reactance, phase shift

PROCEDURE:

1. Measure D-C resistance of small lab test coil. R _____

2. Determine impedance of coil at 100,000 Hz. This can be done by connecting coil in series with variable resistor, applying a-c (sine wave) voltage from signal generator, and adjusting resistance until voltage dropped across resistance is equal to that dropped across coil. Use dual trace oscilloscope with external triggering for voltage measurement. Z_{coil} _____

3. Using results of 1 & 2 above, determine coil reactance _____ and inductance _____

4. Under conditions of 2 above, what is the phase relationship between voltage and current in the coil? (phase of voltage across resistor is same as current in the series circuit since V = IR) _____

5. What is the phase relationship between the applied voltage from the signal generator and current in the series circuit? _____

6. Repeat 3 above using two small lab test coils connected in series. Avoid mutual coupling by keeping coils separated and at right angles to one another.

   reactance _____

   inductance _____

7. Determine the maximum and minimum inductance which may be obtained by intentionally bringing coils as close together as possible.

   L_{max} _____

   L_{min} _____

8. From results of steps 3 and 7 determine the mutual inductance and coefficient of coupling which existed for step 7.

   M _____

   k _____

9. Discuss results and conclusions.

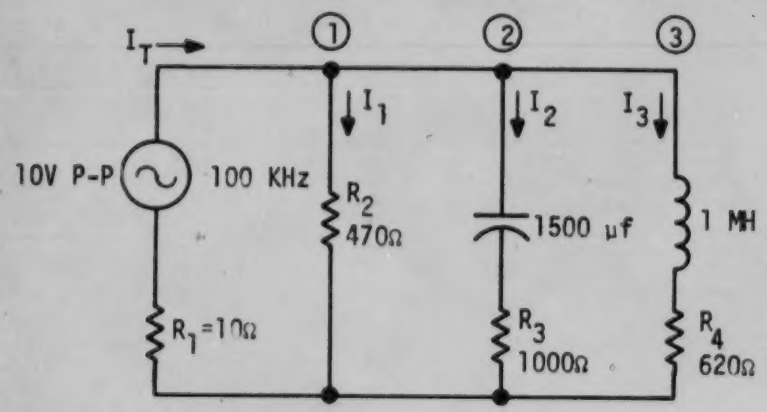
EXP. NO. 3

EL 208
ELECTRONIC COMMUNICATIONS I

Impedance and Phase relationships in Complex circuits.

PROCEDURE:

1. A dual trace oscilloscope with external triggering is to be used for voltage and phase measurements. An isolation transformer should be used with lab signal generator so as to avoid common ground problems between signal generator and oscilloscope.
   Connect the following complex RCL circuit.



Calculate the impedance of branches 1, 2, and 3

Z_1 _____

Z_2 _____

Z_3 _____

Calculate the current which should flow in branches 1, 2, and 3

I_1 _____

I_2 _____

I_3 _____

2. Measure the voltage and phase (with respect to the applied voltage) across

R_1 _____	R_4 _____
R_2 _____	C_1 _____
R_3 _____	L_1 _____

3. Using the above information calculate the current thru branches 1, 2, and 3 and the total current $I = \frac{V}{R}$

I_1 _____	I_3 _____
I_2 _____	I_T _____

4. Knowing the applied voltage and the current indicated in 3 above, calculate the Impedance of branches 1, 2, and 3 and the total parallel impedance. ($Z = \frac{V}{I}$)

Z_1 _____	Z_3 _____
Z_2 _____	Z_T _____

5. Compare calculated values with measured values.

EXP. NO. 4

EL 208
ELECTRONIC COMMUNICATION I

Series Resonance and Q

PROCEDURE:

1. Measure DC resistance of the lab 1 mh. test coil R= _____

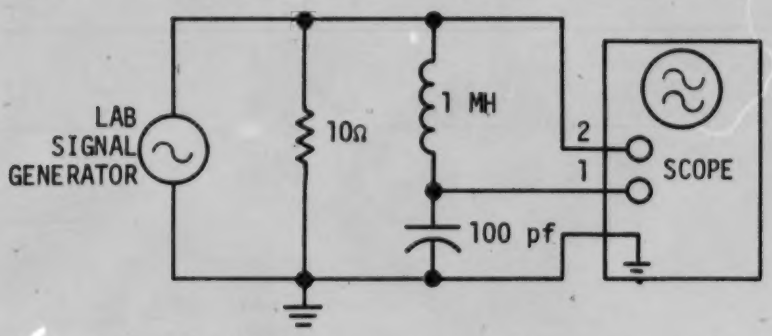
2. Connect test coil in series with a 100 pf. capacitor as shown. Calculate the series resonant frequency, the X_C and X_L. Also anticipated Q at resonance.

   F= _____

   (Remember that source impedance must be accounted for) X_C _____

   X_L _____

   Q= _____



3. With dual trace oscilloscope connected so as to read voltage applied to the series L and C, and across C only, adjust frequency until resonance is indicated by maximum voltage across C. F= _____

   Q of circuit will be indicated by the ratio of $\frac{V_C}{V_{LC}}$ V_{LC} _____

   V_C _____

   measured Q= _____

4. Calculate current in the series LC at resonance.

   $I = \frac{V_C}{X_C}$ I_C= _____

5. Calculate resistance which must be in the circuit.

   $R = \frac{X_C}{Q}$ R_{ac} _____

6. Calculate the bandwidth of the circuit.

   $BW = \frac{f_o}{Q}$ BW _____

7. Determine approximate BW by varying signal generator above and below resonance and recording frequencies at which capacitor voltage drops to 70% of its max value. Explain why this is not an accurate measure of BW.

   f_1 _____

   f_2= _____

   BW= _____

8. Discuss theory of series resonance and any discrepancy between measured and calculated values

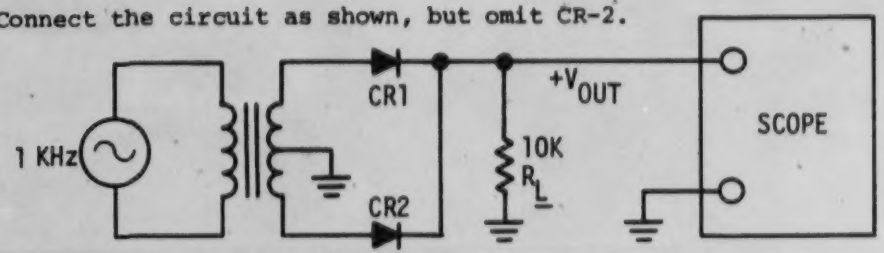
EXP. NO. 5

EL 208
ELECTRONIC COMMUNICATION I

The Full Wave Rectifier

PROCEDURE:

1. Connect the circuit as shown, but omit CR-2.



2. Adjust the source to 1 KHz and so that V_{out} is 3 volts peak. Record V_{out} waveform in space 4a below.

3. Measure the DC voltage across R_L using DC VM _____

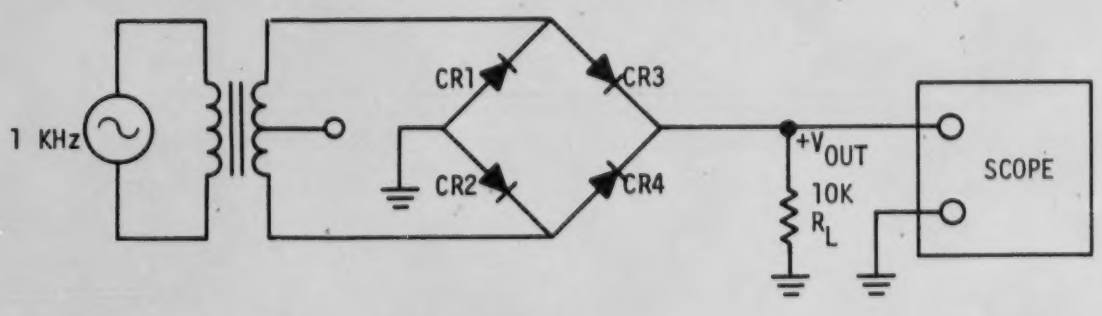
4. Now connect CR-2 and record output waveform at 4b.

4A _____ 4b _____

5. Measure the DC voltage across R_L using DC VM _____

6. Why is there a difference between the voltage measured in step 3 as compared to that measured in step 5, considering that V_{out} peak has not changed?

7. Connect the circuit as shown. Keep the output of the signal generator unchanged from that established for step 2.



8. Record output waveform and DC voltage

9. Compare the results of step 8 with those of 4b and 5. Explain how they are similar and how they are different. (explain does not mean describe)

10. What are the advantages and disadvantages of circuit of step 7 as compared to that of step 4?

EXP. NO. 6

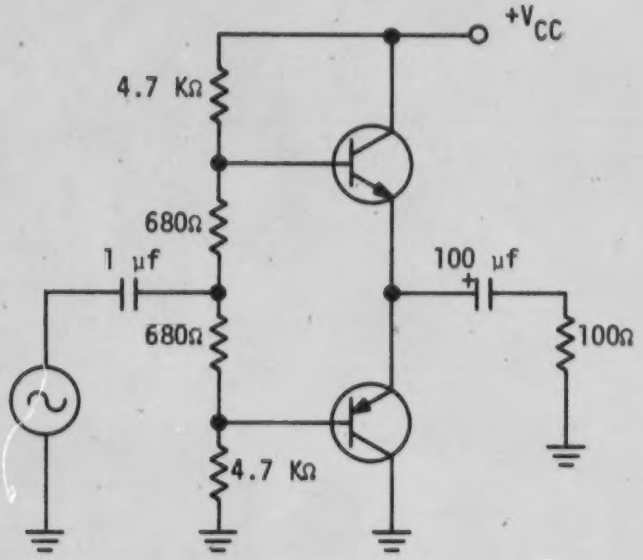
EL 208

ELECTRONIC COMMUNICATIONS 1

Class B Operation

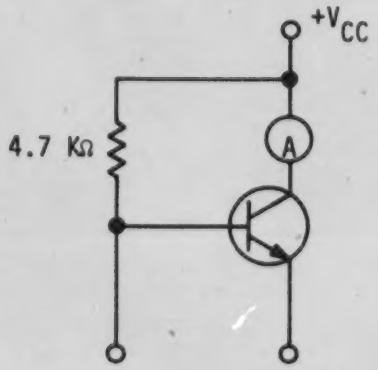
PROCEDURE:

1. Connect circuit as shown using one NPN and one PNP transistor. Use V_{CC} = 5 volts.



2. Set the input frequency to 1 kHz and the signal level across the audio generator to 2 Vpp. Look at the output signal across the 100Ω resistor. What kind of distortion is this? _____

3. Reduce signal input to zero and connect millianmeter in series with upper collector as shown.



4. Slowly increase V_{CC} until I_{CQ} is 1 mA. Remove the meter and reconnect the upper collector to the V_{CC} supply.

5. Increase the signal level until you get an output signal of 8 V_{pp}. Slowly increase the signal level until clipping just starts on the output signal.

6. Using the VOM as an ac voltmeter, measure the rms value of output voltage. Calculate and record the value of load power. _____

7. Explain operation of Class B emitter follower including meaning of cross-over distortion, and why push-pull operation is required.

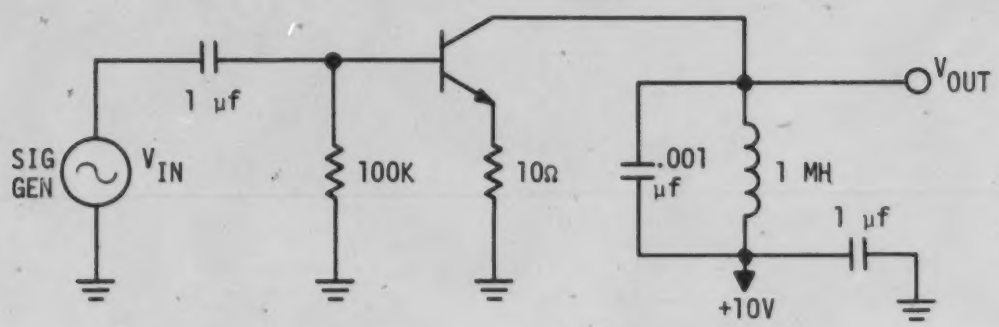
EXP. NO. 7

EL 208
ELECTRONIC COMMUNICATION I

Class C Operation

PROCEDURE:

1. Connect the circuit as shown. Do not apply power.



2. Calculate the resonant frequency of the tank circuit. F_o _____

3. Apply power to circuit. While observing V_{out} adjust signal generator frequency for maximum output at the fundamental frequency. V_{in} approx 5 v p-p.

   V_{in} _____

   F_o _____

4. Record peak to peak value of V_{out} V_o _____

5. Measure pulse width and amplitude of the transistor emitter current.

   i_e _____

   W _____

6. Observe signal on the base of the transistor. Measure the positive and negative peaks of the signal and record waveform.

7. Change frequency of signal generator so that your circuit is operating as a frequency doubler. Use dual trace scope to simultaneously observe emitter current and collector voltage waveform.

8. Determine maximum multiplication that may be obtained from this circuit operating as a multiplier of frequency. (Where amplitude of output maintains 70% of its peak value). Adjust drive if necessary M _____

9. Explain:
   Why is this circuit operating class C?
   How do you know?
   How can circuit operate as a frequency multiplier?
   Why is the base waveform clamped?
   How does tank circuit Q affect operation of Class C stage?

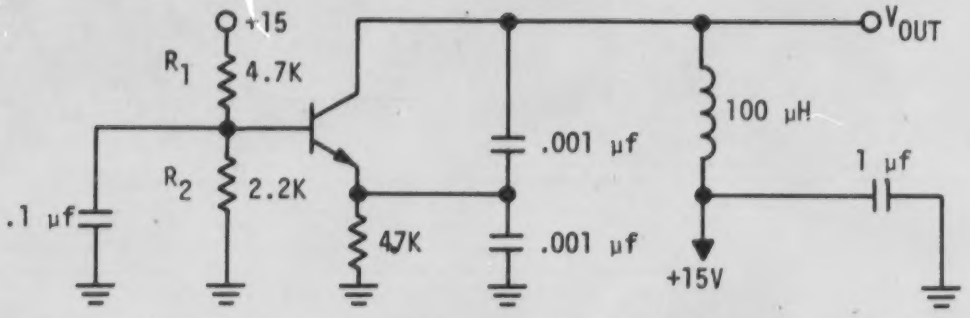
EXP. NO. 8

EL 208
ELECTRONIC COMMUNICATION I

LC Oscillator

PROCEDURE:

1. Connect the circuit as shown. Before applying power calculate the resonant frequency and record here F_o _____



2. Look at the output signal. Measure the period of the output waveforms. T= _____. What frequency does this correspond to? _____

3. Measure output frequency with frequency counter. F_o _____

4. Measure the peak to peak output and record V_{out} _____

5. Connect a 10 K resistor across the output. The output amplitude should decrease. Record the new output voltage and record V_{out} _____

6. How much ac power is there in the 10 K resistor. P_{out} _____

7. Observe the signal across the 4.7 K resistor
   What is its peak to peak value V_e _____

8. Explain:
   What type of oscillator is this? _____

   Why did the signal change when the circuit was loaded with 10 K?

   What value should the inductor be to double the frequency of this circuit?

   What is the purpose of the capacitor from base to ground?

   What is the effective value of the C of the tank circuit?

   What is the purpose of R_1 and R_2?

EXP. NO. 9

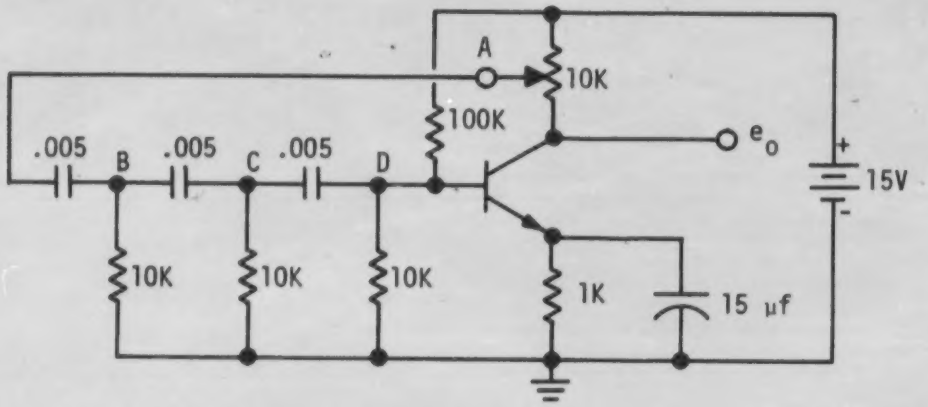
ELECTRONIC COMMUNICATIONS I

Phase Shift Osc.

PROCEDURE:

1. Connect the circuit as shown. Calculate the expected frequency using

$f_o = \frac{1}{2\pi\sqrt{6}\ RC} =$ _____



2. Observe the output waveform on the oscilloscope. Adjust the feedback control so that oscillation is just sustained. Measure the output voltage and frequency

e_o _____

f_o _____

3. Measure the voltage at points A, B, C, D. Determine the attenuation and phase shift of each RC section

		Atten.	Phase
A	_____	_____	_____
B	_____	_____	_____
C	_____	_____	_____
D	_____	_____	_____

4. For this circuit to oscillate, a theoretical gain of 29 for the transistor is predicted. Compare this with the gain which you measured between points A and D. _____ between D and e_o _____

5. Why does this circuit require three RC sections?

6. How does this oscillator differ from the LC oscillator previously tested?

7. If the circuit did not oscillate, what might be the reason?

EXP. NO. 10

EL 208

ELECTRONIC COMMUNICATIONS I

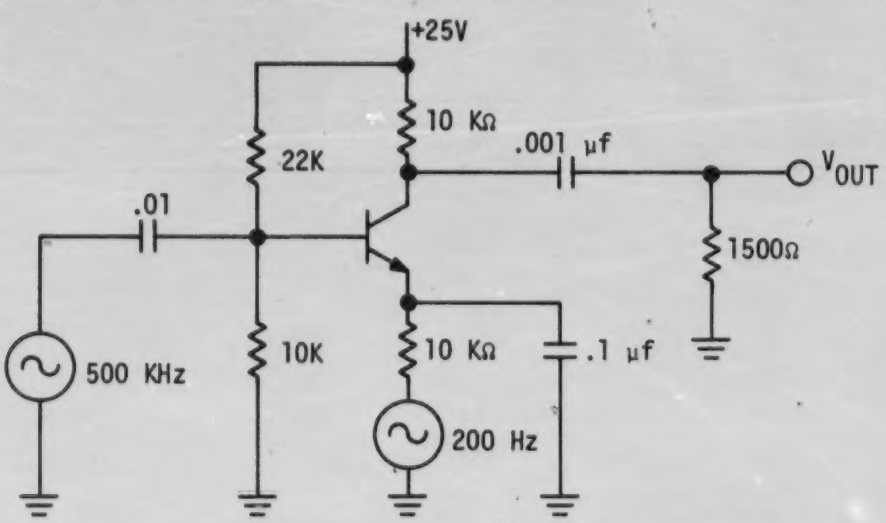
Experiment - Amplitude Modulation

THEORY:

The circuit shown has 2 inputs. The high frequency carrier v_c is the input to a Common Emitter amplifier, and the output of the amplifier will be av_c (where A = gain). The other input to the amplifier is the low frequency modulating signal which becomes a part of the biasing for the amplifier, thus controlling its gain. As the gain of the amplifier varies in accordance with the modulating signal so does the amplitude of the carrier at the amplifier output. Variation of the carrier amplitude in accordance with the modulating signal is known as AMPLITUDE MODULATION.

PROCEDURE:

1. Connect the circuit but do not apply power.



2. Calculate the gain of the amplifier for the carrier. (assume zero modulating signal)

$$A = \frac{r_c}{r_e'} \quad : \quad r_e' \cong \frac{25 \text{ mv}}{I_E} \qquad I_E \cong \frac{V_{th}}{R_E}$$

A_0 = _____

3. If the audio modulating signal has a peak to peak value of 5 volts, what are the minimum and maximum voltage gains for the carrier.

$$I_E \text{ MAX} \cong \frac{V_{th} + v_m \text{ peak}}{R_E} \qquad I_E \text{ MIN} \cong \frac{V_{th} - v_m \text{ peak}}{R_E}$$

A_{max} = _____

A_{min} = _____

4. What is the percent modulation? % mod = $- \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \times 100\%$

5. Turn on power and set the audio generator to zero output. Adjust the RF generator to 500 kHz to get an output from the amplifier of .3 V_{pp} (unmodulated). Measure the RF input signal v_x and record.

V_x _____

6. Calculate the actual value of $A_0 = \frac{v_{out}}{v_x}$ = _____

7. While observing v_{out} on the oscilloscope with sweep speed set to 1 ms/cm slowly increase v_m until you see amplitude modulation. Set v_m to 5 volts p-p and by measuring v_{out} max and v_{out} min calculate the present modulation.

$m = \frac{v_{max} - v_{min}}{v_{max} + v_{min}}$ % mod = _____

8. Observe change in the modulation percentage which occurrs when v_m is changed. Sketch waveform.

EXP. NO. 11

EL 208

ELECTRONIC COMMUNICATIONS I

EXPERIMENT - AM Envelope Detector

THEORY:

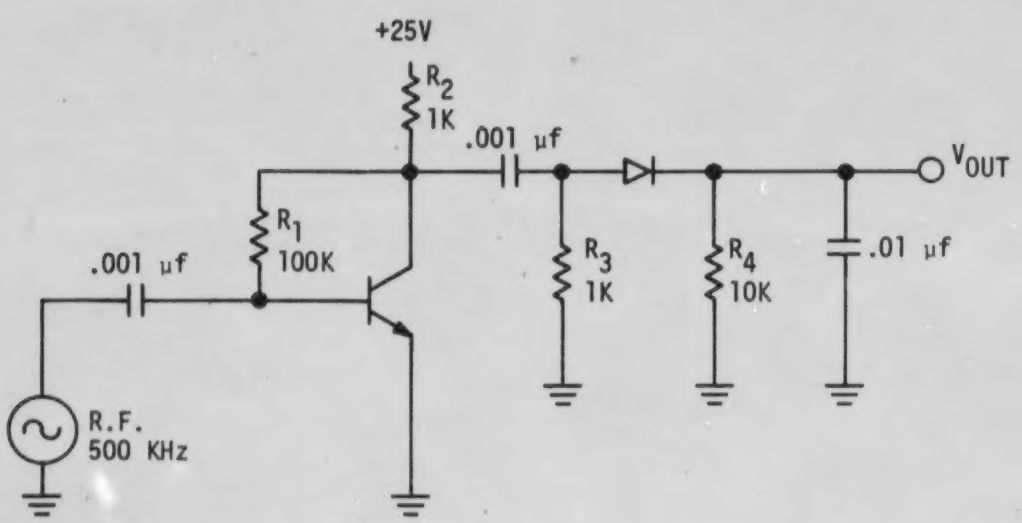
Once an AM signal is received, the carrier must be removed from the modulating signal. Such a circuit is called a Demodulator of Detector. The circuit shown below is one type of Demodulator or Detector. Basically, it is a peak detector which detects the peaks of the input signal so that its output is the upper envelope of the modulated signal. Thus it is sometimes called an envelope detector.

During each carrier cycle, the diode turns on briefly and charges the capacitor to the peak voltage of the particular carrier cycle. Between peaks the capacitor discharges through the resistor. The RC time constant must be much greater than the period of the carrier so that it can discharge only slightly between individual cycles. However, if the time constant is too long, the circuit cannot detect the next carrier peak. The highest envelope frequency the detector can follow without attenuation is given by

$f_{y\,(max)} = \frac{1}{2\pi RCm}$ where m is the modulation coefficient.

PROCEDURE:

Connect the circuit as shown.



1. Determine the highest frequency the envelope detector can follow for a modulation of 30% i.e. m = .3

$f_y m$ = _____

2. With the RF generator set to 500 kHz, unmodulated observe the input to the envelope detector (across R_3) and adjust for a level of 5 V_{pp} with the sweep time at 1 ms/cm/ and sketch below.

3. Turn on modulation of the signal generator and adjust to 30%.

4. Observe the output of the envelope detector, and sketch:

5. Increase RF generator frequency slowly and note highest frequency at which demodulation occurs. Explain.

6. Answer following questions:

   The discharging time constant of the envelope detector is:

   A. The input spectrum to the envelope detector does not contain a(n):

      (a) dc component;
      (b) lower sideband;
      (c) upper sideband;
      (d) carrier.

   B. The output spectrum of the envelope detector contains mostly:

      (a) Carrier;
      (b) lower sideband;
      (c) upper sideband;
      (d) modulating signal.

   C. If the capacitor in the envelope detector is too small, the detected output will have: _____

   D. If the capacitor in the envelope detector is too large, the detected output will have: _____

7. Briefly explain how the envelope detector works.

EXP. NO. 12

ELECTRONIC COMMUNICATIONS I

The Frequency Mixer

Theory: When two sine waves drive a bipolar amplifier in the large signal mode there will be an output spectrum containing each input frequency, all harmonics of these frequencies and the sum and difference frequencies produced by every combination of harmonics.

Group 1. First harmonic of v_x combining with each harmonic of v_y

$f_x \pm f_y$ $\quad$ $f_x \pm 2f_y$ $\quad$ $f_x \pm 3f_y$ etc.

Group 2. Second harmonic of v_x combining with each harmonic of v_y

$2f_x \pm f_y$ $\quad$ $2f_x \pm 2f_y$ $\quad$ $2f_x \pm 3f_y$ etc.

Group 3. Third harmonic of v_x combining with each harmonic of v_y

$3f_x \pm f_y$ $\quad$ $3f_x \pm 2f_y$ $\quad$ $3f_x \pm 3f_y$ etc.

PROCEDURE:

1. If f_x = 51 KHz and f_y = 50 KHz, calculate the group 1, 2 & 3 frequencies.

2. The circuit which you will construct has a twin T filter which has a notch of approximately 50 KHz which would therefore attenuate f_x and f_y. It is followed by a low pass RC filter network which has a break frequency of approximately 10 KHz.
   If the filters stop all frequencies above 10 KHz which of the frequencies calculated in step 1 will appear at the final output.

3. Connect the circuit. Fig. 1. With v_y at zero volts adjust v_x to .1 V pp at approx 51 KHz. Use frequency counter.

4. Adjust v_y to 2 V pp and 50 KHz.

5. Observe the final output signal. Use vertical sensitivity of .1 V/cm(ac) and sweep time at .2 ms/cm. Vary the frequency of v_x until the output is 1 KHz.

6. Observe point B, input to the low pass filter final section and note the ripple on the 1 KHz signal.

7. Observe point A, input to the low pass filter first section.. Notice the much larger ripple is here.

8. Observe voltage at input to twin T filter i.e. collector of transistor. Note that all the frequencies which you calculated in 1 should be present here.

9. Disconnect the twin T filter from the transistor, and from the low pass RC filter which connects to it at point A. Determine its frequency of greatest attenuation by applying a signal generator to its input and observing its output. Determine frequency of greatest attenuation and amount of attenuation.

f_{notch} _____ A _____

10. With the bipolar mixer operating with frequencies of steps 3 & 4, use a lab matching transformer to couple the collector output to audio input of the lab receiver. See diagram below. Fig. 2. Audio input of the receiver is accessible thru the small black shielded wire which originates just behind the switch on the volume control end of the PC card. Use oscilloscope to observe input to the receiver and listen to audible output of receiver.
Vary the frequency of v_y slowly while observing and listening for changes in output.

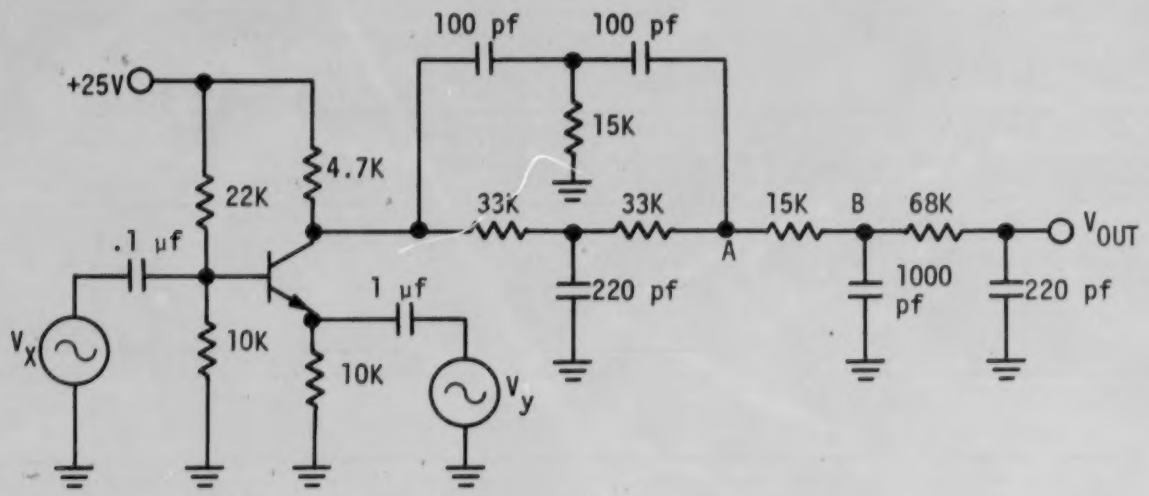


Figure 1

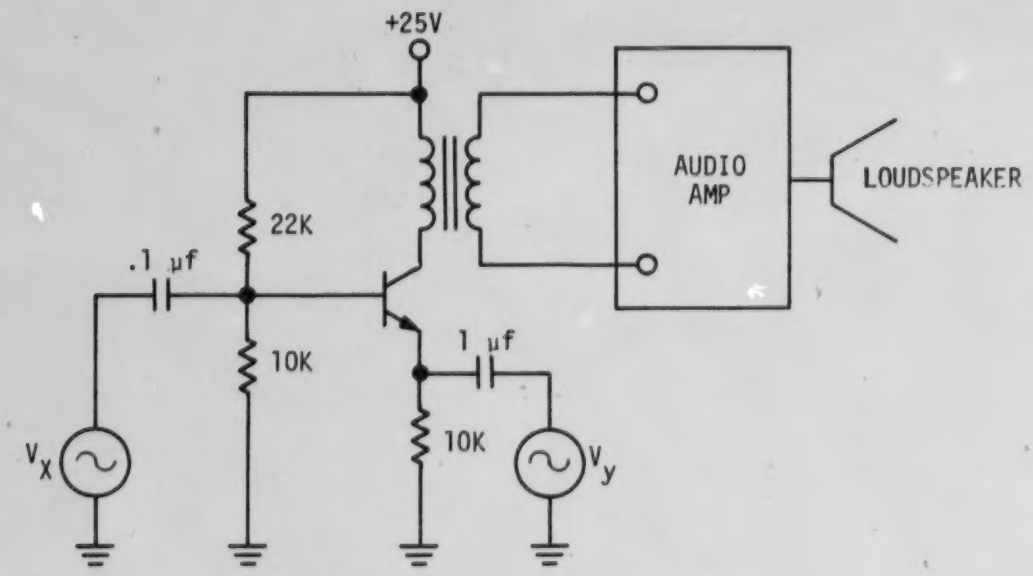


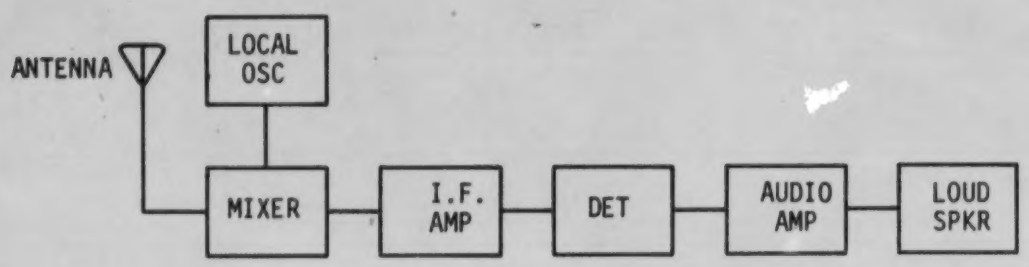
Figure 2

EXP. NO. 13

ELECTRONIC COMMUNICATIONS I

Superheterodyne Receiver

A superheterodyne receiver may be represented by the simple block diagram shown below.



The laboratory test receiver is a superheterodyne type receiver for the AM broadcast band. The purpose of this experiment is to become familiar with the superheterodyne and to determine certain characteristics of the lab receiver.

PROCEDURE: Using clip leads

1. Connect the receiver as indicated:
   a) Blue and red wires to loudspeaker
   b) Brown wire to + terminal of 9 volt supply
   c) Connect - terminal of 9 volt supply to frame of metal jack.
   d) Ignore all other wires and leave them unconnected

2. Connect vertical input of Oscilloscope across loudspeaker terminals so that any voltage applied to it may be observed.

3. Tune in a local broadcast station by adjusting the tuning capacitor. Observe the audio output waveform produced by the station modulation.

4. With the aid of an R.F. signal generator, determine the highest and lowest frequency which can be tuned by the receiver. (its range should be approximately 1500 to 550 KHz. Signal generator "hot" lead should be clipped to an insulated portion of the PC card near the antenna coil. Use 40% internal modulation).

   f_{low} _____

   f_{high} _____

5. Determine the intermediate frequency of the receiver. This can be done by use of RF signal generator to find a frequency which passes through the receiver and is not affected by tuning of the receiver. f_{IF} = _____

6. Set signal generator to 1000 KHz and tune in this signal with your receiver. Determine the frequency of the receiver local oscillator at this time.

   f_{LO} _____

7. Calculate the image frequency which should be received with receiver tuned to 1000 KHz. Remember - that the difference between the received frequency and the local oscillator frequency must equal the Intermediate frequency.

   f_{image} _____

8. Use signal generator to check your calculation.

EXP. NO. 14

EL 208

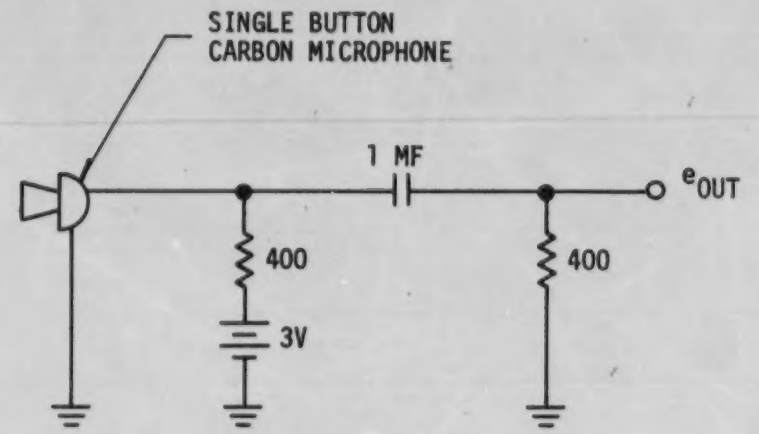
ELECTRONIC COMMUNICATIONS I

Microphones and Loudspeakers

PROCEDURE:

1. Connect ohmmeter across terminals of carbon microphone. Observe how resistance changes as you tap the microphone or whistle into it.

2. Connect circuit as shown.



3. Using oscilloscope observe output waveform as you whistle into microphone.

4. Calculate output level of your whistle in dBm. _____

5. Examine construction of dynamic loudspeaker and describe.

6. Connect signal generator set to 400 Hz, to loudspeaker and adjust output level for comfortable volume.

7. Determine approximate frequency range over which loudspeaker responds by varying signal generator frequency to low and high settings at which you can no longer hear. Your lab. partner should also check since individual hearing ranges differ.

f_{LOW} _____

f_{HIGH} _____

8. Disconnect loudspeaker from signal generator and connect oscilloscope to its terminals. Show that the speaker may function as a microphone by whistling in the vicinity of the cone while observing oscilloscope. Measure max voltage (ac) that is obtainable from whistle. _____

9. Talk into loudspeaker while observing output waveform.

10. Explain how loudspeaker functions as a speaker and as a microphone.

EXP. NO. 15

EL 208

ELECTRONIC COMMUNICATION I

Decibels

PROCEDURE:

1. Figure 1 shows a voltage divider. For each value of R given in Table 1 calculate the bel voltage gain. Round off your answers to the nearest decibel and record the values in Table 1.

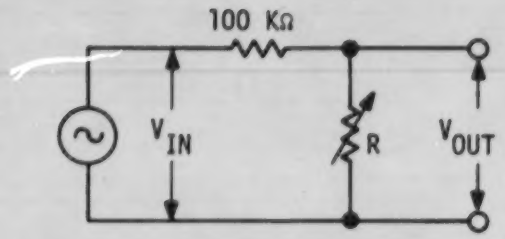


Figure 1

Table 1

R	Calculated A'	Measured A'
240 kΩ		
100 kΩ		
46 kΩ		
11.1 kΩ		
1 kΩ		

2. Connect the circuit of Figure 1 using an R of 240 kΩ.

3. Put the ac millivoltmeter on the 1-V range. Adjust the audio generator to get a v_{in} reading of 0 dB.

4. Measure v_{out} using the dB scale. This reading is the bel voltage gain. Record the value in Table 1 (round off to nearest decibel).

5. Repeat steps 3 and 4 for the other R values listed in Table 1.

6. Figure 2 shows three cascaded voltage dividers. Let $A_1 = v_2/v_1$, $A_2 = v_3/v_2$, and $A_3 = v_4/v_3$. Round off 470 to 500 and calculate the bel voltage gain A_1', A_2', and A_3'. Record in Table 2.

7. Add the foregoing bel voltage gains to get the total bel voltage gain. Record this value as A' in Table 2.

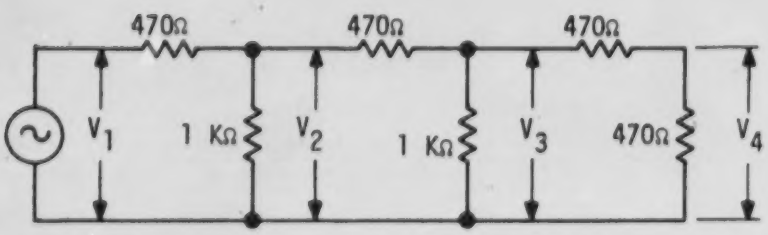


Figure 2

Table 2

A_1' = _____

A_2' = _____

A_3' = _____

A' = _____

8. Connect the circuit of Figure 30b.

9. Set v_1 at 0 dB on the 1-V range of the ac millivoltmeter.

10. Read the values of v_2, v_3, and v_4 rounded off to the nearest decibel and record in Table 3.

Table 3

v_1 = 0 dB

v_2 = _____

v_3 = _____

v_4 = _____

E. PROGRESS TEST NO. 1

EL 208

ELECTRONIC COMMUNICATIONS I

1. In a communications system, noise is most likely to affect the signal

   (a) at the transmitter.

   (b) in the channel.

   (c) in the information source.

   (d) at the destination.

2. Indicate the false statement. Modulation is used to

   (a) reduce the bandwidth used.

   (b) separate differing transmissions.

   (c) ensure that intelligence may be transmitted over long distances.

   (d) allow the use of practicable antennas.

3. An unmodulated carrier:

   (a) cannot transmit intelligence.

   (b) is used for voice transmission.

   (c) is best for code transmission.

   (d) will cause excessive interference.

4. To permit the correct selection of 1 out of 16 equiprobable events, the number of bits required is

   (a) 2.

   (b) 4.

   (c) 8.

   (d) $\log_{10} 16$.

5. The number of bits required to represent 26 letters of the alphabet would be

   (a) 26.

   (b) 5.

   (c) 13.

   (d) 4.

   (e) 3.

   (f) 6.

6. Which is correct?

   (a) Inductive reactance is expressed in volts.

   (b) Inductive reactance is proportional to frequency.

   (c) (both).

   (d) (neither).

7. Which is correct of a series L-R circuit?

   (a) The current is in phase with the voltage across the resistance.

   (b) The current leads the voltage drop across the inductance by 90°.

   (c) (both).

   (d) (neither).

8. Which is correct?

   (a) The line current i flowing in a parallel L-R circuit will be the vector sum of the currents through the resistor and the inductor.

   (b) The current in the inductance leads the current in the resistance by 90°.

   (c) (both).

   (d) (neither).

9. Which is correct when voltage is removed from an R-L circuit?

   (a) After 5 R-L time intervals, the current in an R-L circuit is considered to be zero.

   (b) The current falls to 36.8 percent of its maximum value in the first unit of time.

   (c) (both).

   (d) (neither).

10. Two inductors are connected in series so that no interaction occurs between them. One inductor is 5 millihenries. The other is 6 millihenries. The total inductance of the current is:

   (a) 10 millihenries.

   (b) 80 millihenries.

   (c) 50 millihenries.

   (d) (none of these).

11. What is correct?

(a) Inductive reactance increases the current flowing in an a-c circuit.

(b) $\tan \theta = \frac{Z}{R}$, $|Z| = \sqrt{R^2 + X_L^2}$.

(c) (both).

(d) (neither).

12. When current flows through a capacitor, it:

(a) Leads the applied voltage by 90°.

(b) Lags the applied voltage by 90°.

(c) Is in phase with the applied voltage.

(d) (none of these).

13. In a parallel R-C circuit, impedance may be determined by:

(a) $Z = \frac{X_C R}{X_C^2 + R}$.

(b) $Z = \frac{LR \angle -\theta}{\sqrt{1 + \left(\frac{R}{X_C}\right)^2}}$.

(c) $Z = \frac{E_A}{I_{line}}$.

(d) (none of these).

14. An increase in capacitance or frequency in a series R-C circuit will not result in which of the following changes?

(a) A decrease in X_C.

(b) A decrease in Z.

(c) An increase in θ.

(d) An increase in I_T.

15. A decrease in frequency in a parallel R-C circuit will result in:

(a) decreased X_C.

(b) increased θ.

(c) decreased I_{line}.

(d) (none of these).

16. The time constant of a series R-C circuit:

(a) equals time required for the voltage across a capacitor to charge up to 63.2 percent of the applied voltage.

(b) equals the product of resistance and capacitance.

(c) (both).

(d) (neither).

17. The formula for determining total series-connected capacitance is:

(a) $C_T = \dfrac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$.

(b) $C_T = C_1 + C_2 + C_3$.

(c) $C_T = \sqrt{C_1^2 + C_2^2 + C_3^2}$.

(d) (none of these).

18. The formula for determining total capacitive reactance in a series-connected group of capacitors is:

(a) $X_{C_T} = \dfrac{1}{\frac{1}{X_{C_1}} + \frac{1}{X_{C_2}} + \frac{1}{X_{C_3}}}$.

(b) $X_{C_T} = X_{C_1} + X_{C_2} + X_{C_3}$.

(c) $X_{C_T} = \sqrt{X_{C_1}^2 + X_{C_2}^2 + X_{C_3}^2}$.

(d) (none of these).

19. The formula for determining total capacitance in a parallel-connected group of capacitors is:

(a) $C_T = \sqrt{C_1^2 + C_2^2 + C_3^2}$.

(b) $C_T = \dfrac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$.

(c) $C_T = C_1 + C_2 + C_3$.

(d) (none of these).

20. True power may be determined by:

(a) $P_T = I^2R$.

(b) $P_T = E_{eff} I \frac{R}{Z}$.

(c) $P_T = EI \cos\theta$.

(d) (all of these).

(e) (none of these).

21. Apparent power may be determined by:

(a) $P_a = \frac{E}{I \cos\theta}$.

(b) $P_a = E_{eff} I_{eff} \cos\theta$

(c) $P_a = \left(\frac{E_{max}}{\sqrt{2}}\right)\left(\frac{I_{max}}{\sqrt{2}}\right)$.

(d) (all of these).

(e) (none of these).

22. The power factor of a circuit:

(a) is cos θ.

(b) can be determined by PF = VA.

(c) indicates the relative efficiency of the circuit.

(d) (all of these).

(e) (none of these).

23. The branch currents in a parallel R-L-C circuit may be found with the formula(s):

(a) $I = \frac{E}{X_C}$.

(b) $I = \frac{E}{X_L}$.

(c) $I = \frac{E}{R}$.

(d) (all of these).

24. If capacitive reactance is greater than inductive reactance in a parallel R-L-C circuit:

(a) the circuit phase angle will be negative.

(b) the circuit current leads the applied voltage.

(c) (both).

(d) (neither).

30. At resonant frequency of a series resonant circuit:

(a) inductive reactance is greater than capacitive reactance.

(b) capacitive reactance is greater than inductive reactance.

(c) inductive and capacitive reactance are equal.

(d) (any of these).

31. A given coil has an applied frequency that results in an X_L of 600 ohms, and possesses a d-c resistance of 20 ohms. Which is correct?

(a) Q = 60.

(b) The quality of this coil is the same for all frequencies.

(c) (both).

(d) (neither).

32. The quality of a series resonant circuit can be expressed at the resonant frequency as:

(a) $Q = \frac{X_L}{R}$.

(b) $Q = \frac{E_C}{R}$.

(c) (both).

(d) (neither).

33. The bandwidth of a series resonant circuit:

(a) includes all the frequencies which the circuit will satisfactorily pass.

(b) is described by the frequency lower than f_r, called f_2, and a frequency higher than f_r, called f_1.

(c) (both).

(d) (neither).

34. Which is correct?

(a) The current flow at f_1 and f_2 is 70.7 percent of the current flow at f_r.

(b) The figure of 70.7 percent of maximum current represents one-half the power at resonance.

(c) (both) .

(d) (neither).

35. As the Q of a circuit is decreased:

(a) the circuit current curve becomes steeper.

(b) the bandwidth increases.

(c) (both).

(d) (neither).

36. A circuit has a Q value of 200 and a resonant frequency of 100 hertz. The bandwidth for this circuit is:

(a) 1/2 hertz.

(b) 1 hertz.

(c) 2 hertz.

(d) 10 hertz.

37. After the Q of the circuit has been found:

(a) the bandwidth may be found by using

$$Bw = \frac{f_r}{Q} .$$

(b) the circuit current is calculated.

(c) (both)

(d) (neither).

38. At resonant frequency in a parallel resonant circuit, the branch currents are:

(a) unequal.

(b) 90° out of phase.

(c) 180° out of phase.

(d) (none of these).

39. Which is correct for a parallel resonant circuit:

(a) Below resonant frequency, the circuit appears capacitive.

(b) At resonant frequency, the current decreases to zero.

(c) Above resonant frequency, the circuit appears inductive.

(d) (none of these).

40. In an ideal parallel resonant circuit at resonance:

(a) line current is maximum.

(b) the current flow in the capacitive branch is 90° out of phase with the current flow in the inductive branch.

(c) there is no current flow in the parallel connected branches.

(d) (none of these).

41. Which is correct?

(a) When a parallel circuit is operated above or below resonant frequency, increased line current will be drawn from the circuit.

(b) The reactances of each parallel branch are not equal at resonance.

(c) (both).

(d) (neither).

42. Which is correct?

(a) The d-c resistance contained in the capacitive branch is more than that contained in the inductive branch.

(b) $Q = \frac{X_C X_L}{R}$.

(c) (both).

(d) (neither).

43. Resonant frequency is expressed in:

(a) ohms.

(b) hertz.

(c) amperes.

(d) (none of these).

44. Which is correct?

(a) In a practical parallel L-C circuit, the resistance exists primarily in the inductive branch.

(b) At resonance, $X_L = X_C$.

(c) (both).

(d) (neither).

45. Which is correct?

(a) The Q of a series resonant circuit is determined by the ratio of inductive reactance to total circuit resistance.

(b) The circulating current and the current flowing through the capacitive branch are assumed to be equal in a parallel resonant circuit.

(c) (both).

(d) (neither).

46. A transformer which has 120 volts applied to its primary has a 6 volt secondary with a 1 ampere load. The impedance reflected in the primary is:

(a) 1 ohm.

(b) 120 ohms.

(c) 2400 ohms.

(d) 400 ohms.

47. In a transformer with a purely resistive load:

(a) the voltage and current in the primary are in phase.

(b) the voltage and current in the secondary are 180° out of phase with the primary voltage and current.

(c) (both).

(d) (neither).

48. Which of the following is true?

(a) The equation showing how the voltages of the transformer are related to the turns ratio is $\frac{E_s}{E_p} = \frac{N_p}{N_s}$

(b) The impedance transformation of a transformer is directly proportional to the square of the turns ratio.

(c) (both).

(d) (neither).

49. A transformer has a 110-volt source applied to a 200-turn primary winding. If the secondary has 400 turns, what is the turns ratio and what is the value of secondary voltage?

(a) The turns ratio is 2 and the secondary voltage is 220 volts.

(b) The turns ratio is 1/2 and the secondary voltage is 55 volts.

(c) The turns ratio is 2 and the secondary voltage is 55 volts.

(d) (none of these).

50. A transformer intended to match a 16 ohm loudspeaker to a 6400 ohm amplifier output would have a turns ratio of:

(a) 400 to 1.

(b) 200 to 1.

(c) 20 to 1.

(d) 40 to 1.

(e) (none of above).

51. Which is true?

(a) The cathode of a diode vacuum tube emits electrons and the anode collects electrons.

(b) The anode of a diode tube collects and emits electrons, depending on the direction of the current.

(c) Plate is another word for cathode.

(d) (all of these).

52. Which is correct?

(a) Capacitance exists between any two pieces of metal separated by a dielectric.

(b) The capacitance possessed by the electrodes of a vacuum tube is known as interelectrode capacitance.

(c) (both).

(d) (neither).

53. The amount of capacitance is dependent upon:

(a) the relative size of the metal pieces.

(b) the distance between the metal pieces.

(c) the type of material used for the dielectric.

(d) (all of these).

54. In addition to a control grid a tetrode consists of:

(a) cathode.

(b) screen grid.

(c) plate.

(d) (none of these).

55. The screen grid:

(a) acts like a plate to the electrons attracted toward it.

(b) makes the plate current practically independent of plate voltage.

(c) (both).

(d) (neither).

56. The peak-to-peak output voltage is 600 volts. The peak-to-peak input voltage is 60. Which is correct?

(a) The voltage gain is 10.

(b) They are 90° out of phase.

(c) (both).

(d) (neither).

57. Increasing the negative voltage applied to the grid of the triode will cause:

(a) the plate current to decrease.

(b) a greater plate voltage to be required to create a plate current.

(c) (both).

(d) (neither).

58. A pentode:

(a) is a four-element tube.

(b) contains a suppressor grid.

(c) (both).

(d) (neither).

59. Pentodes:

(a) have less interelectrode capacitance than tetrodes.

(b) contain a suppressor grid.

(c) (both).

(d) (neither).

60. In a triode operating with a constant 15 milliampers of plate current it is found that the plate voltage changes by 20 volts when a 5 volt signal is applied to the grid. The amplification factor for the triode is:

(a) 10 with 15 milliamperes of plate current.

(b) 13 with a grid voltage of 5 volts.

(c) 4 with 15 milliamperes of plate current.

(d) 20 with 15 milliamperes of plate current.

61. Which is correct of a triode?

(a) The current through the plate load resistance is in two directions.

(b) The input signal, at the control grid, is smaller in amplitude than the signed developed across the plate load resistor.

(c) (both).

(d) (neither).

62. A triode:

(a) is used to control plate voltage.

(b) has three elements, the cathode, the plate, and a control grid.

(c) (both).

(d) (neither).

63. When the grid voltage of a triode is increased in the negative direction:

(a) the plate current will decrease.

(b) the plate voltage will decrease.

(c) (both).

(d) (neither).

64. The amount of grid voltage necessary to cause cutoff:

(a) depends on the plate voltage.

(b) increases as the plate voltage increases.

(c) (both).

(d) (neither).

65. Bias voltage is:

(a) the voltage applied to the plate of a triode.

(b) a d-c difference in potential between the cathode and the control grid.

(c) (both).

(d) (neither).

66. Bias voltage:

(a) is usually used to make the grid negative with respect to the cathode.

(b) causes the plate current to increase indefinitely.

(c) (both).

(d) (neither).

67. The process of rectification:

(a) is the changing of d-c voltage to pulsating a-c voltage.

(b) converts a-c input voltage to d-c output voltage.

(c) (both).

(d) (neither).

68. A basic principle of diode tubes is:

(a) bidirectional current.

(b) unidirectional current.

(c) alternating current.

(d) (none of these).

69. A resistor of 8 ohms is connected in series with a capacitive reactance of 6 ohms. The resultant total impedance is:

(a) 14 ohms.

(b) 2 ohms.

(c) 10 ohms.

(d) 48 ohms.

70. An inductance of 1 MH is connected in parallel with a capacitor of 1000 pf. The parallel resonant frequency is:

(a) 159 Hz.

(b) 1000 KHz.

(c) 4.3 MHz.

(d) 159 KHz.

(e) (none of above).

F. PROGRESS TEST NO. 2

EL 208

ELECTRONIC COMMUNICATION I

1. Audio amplifiers amplify signals in the frequency range:

   (a) above 30,000 megahertz.
   (b) between 30,000 hertz and 30,000 megahertz.
   (c) between 10,000 hertz and 40,000 kilohertz.
   (d) below 20,000 hertz.

2. Frequency distortion occurs when:

   (a) all frequencies are amplified equally.
   (b) some frequencies are amplified more than others.
   (c) unwanted harmonics are generated.
   (d) phase inversion occurs.

3. The most common type of amplifier stage coupling is:

   (a) impedance coupling.
   (b) transformer coupling.
   (c) R-C coupling.
   (d) direct coupling.

4. In direct coupling, the collector of one transistor is coupled directly to:

   (a) the base of the next.
   (b) the collector of the next.
   (c) the emitter of the next.
   (d) its own base.

5. R-C coupling in an a-f voltage amplifier provides:

   (a) fairly low collector current.
   (b) amplification of a single frequency.
   (c) a light and inexpensive voltage amplifier.
   (d) fairly uniform gain over the audio range.

6. An impedance-coupled a-f voltage amplifier:

   (a) provides fairly uniform gain over the audio range.

   (b) uses a transformer for impedance matching.

   (c) effectively amplifies only a single frequency or narrow band of frequencies.

   (d) is identical to an R-C coupled amplifier.

7. The most efficient class of amplifier operation is:

   (a) Class A.

   (b) Class B.

   (c) Class C.

   (d) Class AB.

8. A feedback network compensates for:

   (a) changes in bias.

   (b) frequency multiplication.

   (c) phase inversion.

   (d) large changes in gain.

9. The parameters of the transistors used in an amplifier:

   (a) are determined by the manufacturer.

   (b) may change with age.

   (c) determine the performance of the transistor.

   (d) (all of these).

10. A feedback network:

    (a) feeds some of the input signal into the amplifier output.

    (b) increases the gain of an amplifier.

    (c) is external to the amplifier circuit.

    (d) (none of these).

11. The gain of an emitter-follower circuit:

    (a) is always less than one.

    (b) can be increased with a feedback network.

    (c) is the ratio of output current to input voltage.

    (d) (none of these).

12. A paraphase amplifier:

(a) has a gain of less than one.

(b) is always a phase inverter.

(c) has output signal amplitude greater than input amplitude.

(d) produces two output signals of the same phase.

13. An a-f power amplifier is designed to amplify:

(a) only the current.

(b) only the voltage.

(c) voltage more than current.

(d) current more than voltage.

14. Audio-frequency power amplifiers:

(a) cannot use transformer coupling at the output.

(b) amplify signals in the range above 20,000 hertz.

(c) can be single-ended or push-pull.

(d) (all of these).

15. A class A amplifier is one in which current flows for:

(a) one half of the ac cycle.

(b) 180° of the ac cycle.

(c) 360° of the ac cycle.

(d) 120° of the ac cycle.

(e) (none of above).

16. Class C amplifiers are usually used for:

(a) high fidelity audio amplification.

(b) frequency multiplication.

(c) high power audio amplification.

(d) low power R.F. amplification.

(e) frequency conversion.

17. When a vacuum tube is used as a Class B amplifier, it will be biased so that :

(a) it is at cut-off with no signal.

(b) current flows for less than 180° of the ac cycle.

(c) good frequency multiplication results.

(d) power dissipation is maximum.

(e) it produces less power than Class A.

18. Class B audio amplifiers:

(a) have more distortion than Class C amplifiers.
(b) are usually used for frequency multiplication.
(c) do not require neutralization.
(d) must be used in push-pull.
(e) (none of above).

19. An oscillator circuit oscillates at a frequency:

(a) provided by the a-c input signal.
(b) determined by the constants of the circuit.
(c) equal to the value of its components.
(d) (none of these).

20. A capacitor attains a charge almost equal to the applied voltage.

(a) as R-C discharging occurs.
(b) when the resonant frequency is reached.
(c) when the R-C time constant is zero.
(d) after five time constants.

21. When feedback is out of phase with the input voltage, it is called:

(a) negative feedback.
(b) positive feedback.
(c) regeneration.
(d) degeneration.

22. An audio-frequency oscillator can be considered:

(a) an a-f amplifier.
(b) a filter circuit.
(c) a source of alternating current.
(d) a feedback network.

23. Radio-frequency oscillators are found in every:

(a) loudspeaker.
(b) radio receiver.
(c) radio transmitter.
(d) antenna.

24. Any desired phase shift can be obtained by:

(a) using the appropriate values in an R-C circuit.

(b) cascading several R-C circuits.

(c) (both).

(d) (neither).

25. The output of the R-C phase shift oscillator is:

(a) direct current.

(b) in phase with its input.

(c) an almost pure sine wave.

(d) a straight line.

26. The R-C phase shift oscillator is well adapted for:

(a) superheterodyne receivers.

(b) radio transmitters.

(c) all frequency bands.

(d) audio-frequency applications.

27. Another name for an L-C oscillator, which uses a tuned circuit made up of inductors and capacitors, is the:

(a) crystal-controlled oscillator.

(b) phase-shifting oscillator.

(c) r-f oscillator.

(d) self-excited oscillator.

28. An Armstrong oscillator circuit:

(a) is always crystal controlled.

(b) uses a tickler coil.

(c) uses an R-L phase-shift circuit.

(d) will oscillate without adjusting the feedback.

29. A Hartley oscillator is:

(a) one with tapped tank coil.

(b) always series fed.

(c) constructed with a tickler coil.

(d) crystal controlled.

(e) seldom used.

30. The Colpitts oscillator:

(a) uses a capacitor voltage divider.

(b) is crystal controlled.

(c) uses a tickler coil.

(d) uses an autotransformer.

31. The output of an L-C oscillator is:

(a) not affected by climate.

(b) less stable than the output of a crystal-controlled oscillator.

(c) independent of transistor properties.

(d) (all of these).

32. The Armstrong oscillator can be modified into a crystal-controlled oscillator by:

(a) replacing the tuned circuit with a crystal.

(b) replacing the tickler coil with a crystal.

(c) inserting a crystal into the L-C circuit.

(d) inserting a crystal into the feedback path.

33. The Pierce crystal oscillator:

(a) operates in a series-resonant mode.

(b) has a crystal in addition to an L-C circuit.

(c) has a crystal with no tuned circuit.

(d) produces a very high output.

34. Broadcast transmitters use the following type of oscillator circuit:

(a) Hartley.

(b) Colpitts.

(c) Pierce.

(d) Crystal.

(e) Armstrong.

35. A crystal controlled oscillator:

(a) does not change frequency as its temperature changes.

(b) is too expensive for use in low powered transmitters.

(c) requires no feedback circuit.

(d) is seldom found in modern transmitters.

(e) has a frequency determined by the thickness of its crystal.

36. Quartz crystals:

(a) are used as found in nature.

(b) provide a low Q .

(c) may have positive or negative temperature coefficient.

(d) are used where a Hartley oscillator might be too expensive.

37. An incomplete input cycle can produce a sine-wave output because of the:

(a) collector tank oscillation.

(b) buffer amplifier.

(c) frequency multiplier.

(d) flywheel effect.

38. A circuit that produces an output of twice the input frequency is called a:

(a) frequency divider.

(b) doubler.

(c) buffer.

(d) (all of these).

39. A frequency multiplier usually operates class:

(a) A.

(b) B.

(c) AB.

(d) C.

40. A circuit that isolates the oscillator voltage from later stages is called:

(a) a frequency multiplier.

(b) an r-f buffer.

(c) an isolation circuit.

(d) an a-f amplifier.

41. The tank of a frequency multiplier is resonant to:

(a) the applied signal.

(b) some frequency below 20 kilohertz.

(c) a harmonic of the applied signal.

(d) (none of these).

42. A transistor whose output is a fundamental frequency plus reduced-amplitude harmonics:

(a) produces amplitude distortion.

(b) is an oscillator.

(c) functions as a buffer.

(d) is a doubler.

43. An amplifier that delivers large current values to a load is called a:

(a) voltage amplifier.

(b) power amplifier.

(c) current amplifier.

(d) radio-frequency amplifier.

44. Unwanted oscillations in an amplifier are usually prevented by:

(a) a buffer amplifier.

(b) a frequency multiplier.

(c) a resonant tank.

(d) neutralization.

45. R-F power amplifiers usually operate class:

(a) A.

(b) B.

(c) AB.

(d) C.

46. An r-f signal in a transmitter is produced by the:

(a) amplifiers.

(b) frequency multipliers.

(c) modulator.

(d) oscillator.

47. A transmitter which needs to produce many frequencies would use a:

(a) crystal-controlled oscillator.

(b) variable-frequency oscillator.

(c) Pierce oscillator.

(d) (any of these).

48. Oscillators can be coupled to a load in a transmitter by:

(a) direct coupling.
(b) capacitive coupling.
(c) inductive coupling.
(d) link coupling.
(e) (all of above).
(f) (none of above).

49. Every radio transmitter must:

(a) generate an r-f signal.
(b) modulate the a-f signal.
(c) detect the signal.
(d) radiate an r-f wave.

50. The output of an m-o-p-a transmitter is usually:

(a) connected to an antenna.
(b) a discontinuous wave.
(c) an amplitude-modulated wave.
(d) an audio signal.

51. A frequency multiplier is most likely to be used in a(n):

(a) c-w transmitter.
(b) m-o-p-a transmitter.
(c) vhf transmitter.
(d) high-power transmitter.

52. To eliminate self-oscillation in amplifier stages, they must be:

(a) coupled.
(b) crystallized.
(c) neutralized.
(d) stable.

53. When the output of an amplifier closely follows the input waveform:

(a) distortion is present.
(b) it is modulated.
(c) the amplification value is 1.
(d) it is a linear amplifier.

54. Oscillations other than the fundamental frequency are called:

(a) parasitics.

(b) self-excited oscillations.

(c) harmonicas

(d) chromatics.

55. An electrostatic, or Faraday, shield is used to:

(a) suppress parasitics.

(b) suppress the fundamental frequency.

(c) suppress harmonics.

(d) decrease the power output from a transmitter.

56. The radio-frequency output of a c-w transmitter should be:

(a) zero when the key is open.

(b) maximum at all times.

(c) twice the carrier frequency.

(d) maximum when the key is open.

57. An unstable oscillator in a c-w transmitter can cause:

(a) clicks.

(b) snaps.

(c) chirps.

(d) key noise.

58. Frequency cannot be measured with:

(a) a frequency meter.

(b) an electronic counter.

(c) a calibrated receiver.

(d) a wavemeter.

(e) a signal calibrated generator.

59. The actual radiated power at the transmitter antenna:

(a) is less than the input power to the final amplifier stage.

(b) is equal to the applied collector voltage times the collector current.

(c) (both).

(d) (neither).

G. PROGRESS TEST NO. 3

EL 208

ELECTRONIC COMMUNICATION I

1. The frequency is fixed and the amplitude is variable in an:

   (a) AM waveform.

   (b) FM waveform.

   (c) (both).

   (d) (neither).

2. The percentage of modulation of an amplitude-modulated wave:

   (a) is measured by a wavemeter.

   (b) is greater than 100 percent for minimum distortion.

   (c) determines the amount of power in the wave.

   (d) should approach but not exceed 90 percent.

3. The power in the carrier wave:

   (a) varies with the percentage of modulation.

   (b) is equal to the power in one sideband.

   (c) is always constant.

   (d) is greatest when the percentage of modulation is 100 percent.

4. Modulation measurement may be done with:

   (a) an electronic counter.

   (b) an oscilloscope.

   (c) a trapezoid.

   (d) a wavemeter.

5. The modulation percentage of an AM wave is changed from 0 to 100%. The transmitted power is:

   (a) unchanged.

   (b) halved.

   (c) doubled.

   (d) increased by 50 percent.

6. If the carrier of a 100 percent modulated AM wave is suppressed, the percentage power saving will be:

   (a) 50.

   (b) 150.

   (c) 100.

   (d) 66.66.

7. If the plate supply voltage for a plate-modulated class C amplifier is E, the maximum plate-cathode voltage could be almost as high as:

   (a) 4E.

   (b) 3E.

   (c) 2E.

   (d) E.

8. In a low-level AM system, amplifiers following the modulated stage must be:

   (a) linear devices.

   (b) harmonic devices.

   (c) class C amplifiers.

   (d) nonlinear devices.

9. Twice the bandwidth of the original modulating signal is required in:

   (a) standard amplitude modulation.

   (b) SSB transmission.

   (c) (both).

   (d) (neither).

10. In SSB transmission the carrier frequency can be:

    (a) suppressed.

    (b) reduced.

    (c) transmitted in full.

    (d) (all of these).

11. SSB transmission can provide the same area of coverage as DSB transmission with as little as:

    (a) one-half the power.

    (b) one-fourth the power.

    (c) one-eighth the power.

    (d) (none of these).

12. When the output of a radio transmitter is modulated 100% the antenna current will increase by:

(a) 50%.

(b) 100%.

(c) 22.5%.

(d) 25%.

(e) 400%.

13. Indicate the false statement regarding the advantages of SSB over double-sideband, full-carrier AM.

(a) More channel space is available.

(b) Transmitter circuits must be more stable, giving better reception.

(c) The signal is more noise-resistant.

(d) Much less power is required for the same signal strength.

14. When the modulation index of an AM wave is doubled, the antenna current is also doubled. The AM system being used is:

(a) exclusively SSB.

(b) double-sideband suppressed-carrier exclusively.

(c) double-sideband suppressed-carrier or SSB.

(d) double-sideband AM with full carrier.

15. The signal is said to be 100-percent modulated when an FM station uses:

(a) the entire allowed deviation.

(b) a deviation of 150 kilohertz.

(c) (both).

(d) (neither).

16. In FM transmitters a change in a reactive component of the oscillator tank is used to cause a frequency shift when a:

(a) mechanical modulator is used.

(b) varactor-diode modulator is used.

(c) phase modulator is used.

(d) (all of these).

17. In phase modulation in an FM transmitter, the phase modulator:

(a) follows the master oscillator.

(b) precedes the multiplier stages.

(c) (both).

(d) (neither).

18. In the spectrum of a frequency-modulated wave:

(a) the carrier frequency disappears when the modulation index is large.

(b) the amplitude of any sideband depends on the modulation index.

(c) the total number of sidebands depends on the modulation index.

(d) the carrier frequency cannot disappear.

19. The difference between phase and frequency modulation.

(a) is purely theoretical because they are the same in practice.

(b) is too great to make the two systems compatible.

(c) lies in the poorer audio response of phase modulation.

(d) lies in the different definitions of the modulation index.

20. To determine the modulation index of an FM signal:

(a) Find the number of sidebands.

(b) Apply the number of sidebands to a set of equations known as the Bessel functions.

(c) (both).

(d) (neither).

21. The output of an amplitude-modulated transmitter is:

(a) a very high current.

(b) a modulated wave envelope.

(c) a constant audio frequency.

(d) always of constant amplitude.

22. A preemphasis circuit provides extra noise immunity by:

(a) boosting the bass frequencies.

(b) amplifying the higher audio frequencies.

(c) preamplifying the whole audio band.

(d) converting the phase modulation to FM.

23. Indicate which one of the following is not an advantage of FM over AM:

(a) Better noise immunity is provided.

(b) Lower bandwidth is required.

(c) The transmitted power is more useful.

(d) Less modulating power is required.

24. A received signal in the range from 20 kilohertz to 300 megahertz is amplified by an:

(a) a-f amplifier.

(b) r-f amplifier.

(c) i-f amplifier.

(d) (all of these).

25. An i-f amplifier amplifies a frequency that is always:

(a) within the radio-frequency range.

(b) above the received signal.

(c) below the received signal.

(d) within the audio-frequency range.

26. In ratio detection:

(a) a limiter stage is not needed to eliminate amplitude modulation.

(b) the limiter circuit amplifies the signal and removes amplitude variations from its i-f input.

(c) (both).

(d) (neither).

27. In an SSB receiver:

(a) the carrier must be locally generated if reduced carrier transmission is used.

(b) the signal must be amplified and reinserted if the transmission is SSSC.

(c) (both).

(d) (neither).

28. An FM signal with a modulation index m_f is passed through a frequency tripler. The wave in the output of the tripler will have a modulation index of:

(a) $m_f/3$. (c) $3\ m_f$

(b) m_f. (d) $9\ m_f$

29. In an SSB transmitter, one is most likely to find a:

(a) class C audio amplifier.

(b) tuned modulator.

(c) class B RF amplifier.

(d) class A RF output amplifier.

30. Indicate which of the following statements about the advantages of the phase discriminator over the slope detector is false:

(a) Much easier alignment.

(b) Better linearity.

(c) Greater limiting.

(d) Fewer tuned circuits.

31. In a broadcast superheterodyne receiver, the

(a) local oscillator operates below the signal frequency.

(b) mixer input must be tuned to the signal frequency.

(c) local oscillator frequency is normally double the IF.

(d) RF amplifier normally works at 455 KHz above the carrier frequency.

32. A superheterodyne receiver with an IF of 450 KHz is tuned to a signal at 1,200 KHz. The image frequency is

(a) 750 KHz.

(b) 900 KHz.

(c) 1,650 KHz.

(d) 2,100 KHz.

33. The most common modulation system used for radiotelegraphy is:

(a) frequency-shift keying.

(b) two-tone modulation.

(c) pulse-code modulation.

(d) single-tone modulation.

34. A relatively high-Q tuned circuit will increase:

(a) the amplification of weak signals.

(b) the image interference of the t-r-f receiver.

(c) the selectivity of the t-r-f receiver.

(d) the signal-to-noise ratio.

35. The intermediate frequency is the:

(a) local oscillator frequency.

(b) sum of the oscillator and received signal frequencies.

(c) difference between the oscillator and received signal frequencies.

(d) difference between the received and desired output frequencies.

36. Frequency conversion in a superheterodyne receiver is done by:

(a) a mixer circuit and a local oscillator.

(b) i-f amplifiers.

(c) critical coupling in the antenna.

(d) a transistor circuit.

37. A receiver that uses an intermediate frequency is a:

(a) tuned-radio-frequency receiver.

(b) crystal receiver.

(c) superheterodyne receiver.

(d) (any of these).

38. Signal interception in a crystal receiver is performed by the:

(a) crystal oscillator.

(b) detector.

(c) headset.

(d) antenna.

39. For detection, modern crystal sets use a:

(a) tuned L-C circuit.

(b) galena crystal.

(c) semiconductor diode.

(d) field-effect transistor.

40. A crystal receiver does not perform.

(a) reproduction.

(b) amplification.

(c) demodulation.

(d) selection.

41. Signal selection in a t-r-f receiver is performed by:

(a) r-f amplifiers.

(b) a-f amplifiers.

(c) i-f amplifiers.

(d) antenna coupling circuits.

42. In order to distort the signal as little as possible, r-f amplifiers in a t-r-f receiver are:

(a) triple tuned.

(b) operated class A.

(c) located before the antenna coupling circuits.

(d) similar to those in a crystal receiver.

43. The measure of the ability of a receiver to amplify weak signals is called its:

(a) sensitivity.

(b) selectivity.

(c) signal-to-noise ratio.

(d) amplification factor.

44. The difference between the intermediate frequency and the image frequency is:

(a) dependent on the oscillator frequency.

(b) always twice the intermediate frequency.

(c) never greater than 455 kilohertz.

(d) (none of these).

45. Tracking at high frequencies in a superheterodyne receiver is ensured by the use of:

(a) a-g-c circuits.

(b) padder capacitors.

(c) bleeder resistors.

(d) trimmer capacitors.

46. A horizontally polarized antenna:

(a) has its magnetic field horizontal.

(b) has its electric field horizontal.

(c) is physically horizontal.

(d) is more effective.

47. The highest frequency that returns to earth from vertical transmission under given atmospheric conditions is:

(a) in the vhf range.

(b) called the maximum usable frequency.

(c) called the critical frequency.

(d) always higher than 30 megahertz.

48. A ship-to-ship communications system is plagued by fading; the best solution seems to be the use of:

(a) a more directional antenna.

(b) a broadband antenna.

(c) frequency diversity.

(d) space diversity.

49. Radio waves travel at the speed of:

(a) water waves.

(b) 186,000,000 miles per second.

(c) 300,000,000 meters per second.

(d) sound waves.

50. The frequency that gives the most consistent communication at a given distance is called the:

(a) maximum usable frequency.

(b) optimum working frequency.

(c) critical frequency.

(d) (none of these).

51. The formula for the characteristic impedance of a coaxial transmission line is:

(a) $Z_o = 138 \log_{10} \frac{D}{d}$.

(b) $\lambda = \frac{300,000,000}{f}$.

(c) $Z_o = 275 \log_{10} \frac{2D}{d}$.

(d) $SWR = \frac{I_{max}}{I_{min}}$.

52. The relationship between wavelength and frequency is found by:

(a) $\lambda = \frac{v}{f}$.

(b) $T = RC$.

(c) $f = v\lambda$.

(d) $f = \frac{1}{2\pi \sqrt{LC}}$

53. An untuned transmission line:

(a) is resonant.

(b) terminates in its characteristic impedance.

(c) is only useful over a narrow frequency.

(d) (all of these).

54. Transmission lines are not used to:

(a) connect transmitter and loudspeaker

(b) feed antennas.

(c) correct impedance mismatch.

(d) act as step-up or step-down transformers.

55. Indicate which of the following reasons for using a counterpoise with antennas is false:

(a) Impossibility of a good ground connection.

(b) Protection of personnel working underneath.

(c) Provision of an earth for the antenna.

(d) Rockiness of the ground itself.

56. One of the following is not a reason for the use of an antenna coupler:

(a) To make the antenna look resistive.

(b) To provide the output amplifier with the correct load impedance.

(c) To discriminate against harmonics.

(d) To prevent reradiation of the local oscillator.

57. A radio transmitter operating on a frequency of 500 KHz radiates a signal having a wavelength of:

(a) 200 meters.

(b) 600 meters.

(c) 10 meters.

(d) 6500 meters.

(e) (none of these).

58. One of the reasons why vacuum tubes eventually fail at microwave frequencies is that their:

(a) noise figure increases.

(b) transit time becomes too short.

(c) shunt capacitive reactances become too large.

(d) series inductive reactances become too small.

59. Electromagnetic waves are refracted when they:

(a) pass into a medium of different dielectric constant.

(b) are polarized at right angles to the direction of propagation.

(c) encounter a perfectly conducting surface.

(d) pass through a small slot in a conducting plane.

60. Top loading is sometimes used with an antenna in order to increase its:

(a) effective length.

(b) bandwidth.

(c) beamwidth.

(d) input capacitance.

61. The transducer in a phonograph pickup converts:

(a) mechanical energy to electrical energy.

(b) electrical energy to audio energy.

(c) audio energy to mechanical energy.

(d) mechanical energy to sound.

62. The early crystal receivers used:

(a) vacuum tubes.

(b) loudspeakers.

(c) electromagnets.

(d) headsets.

63. Microphones are made to convert:

(a) sound energy to electrical energy.
(b) sound energy to heat energy.
(c) electrical energy to sound energy.
(d) electrical energy to heat and sound energy.

64. The type of microphone usually found in telephones is the:

(a) crystal microphone.
(b) velocity-ribbon microphone.
(c) single-button carbon microphone.
(d) double-button carbon microphone.

65. The double-button carbon microphone operates like a:

(a) single-button carbon microphone.
(b) push-pull amplifier.
(c) crystal microphone.
(d) (all of these).

66. The crystal and capacitor microphones:

(a) are amplitude responding.
(b) are velocity responding.
(c) are extremely rugged.
(d) have poor frequency response.

67. The basic purpose of loudspeakers is to produce:

(a) sound waves that corresponds to the modulated signal.
(b) sound waves that corresponds to the applied a.c. voltage.
(c) electrical energy that corresponds to the audio input.
(d) electrical energy that corresponds to the applied voltage.

68. An antenna that is one quarter wavelength long is likely to be called a:

(a) Hertz antenna.
(b) Marconi antenna.
(c) Yagi antenna.
(d) vertical antenna.

69. An antenna that is end fed and is one half wavelength long is likely to be called a:

(a) Hertz antenna.

(b) Marconi antenna.

(c) Collinear antenna.

(d) Long wire antenna.

(e) Horizontal antenna.

70. A carbon microphone converts sound waves into variations of:

(a) current.

(b) voltage.

(c) resistance.

(d) inductance.

H. FINAL EXAM

EL 208

ELECTRONIC COMMUNICATION NO. 1

1. When triodes are used as RF amplifiers, it is necessary to _____ the grid-plate capacity.

2. In order to insure that any signal in the plate circuit is due to inter-electrode capacity it is necessary to _____ the _____ as a first part of the neutralization procedure.

3. If a certain fundamental frequency is 400 Hz, then the second harmonic would be _____.

4. When an AM transmitter is modulated 100% by a sine wave, the antenna current will be increased by _____ over its unmodulated value.

5. When a radiofrequency carrier is modulated 100% by a sine wave of audio frequency, the average power will increase by _____ over the unmodulated value (in amplitude modulation).

6. If a 1000 KHz carrier is amplitude modulated by a 1000 Hz sine wave what are the frequencies of the two side bands? _____&_____.

7. If the percentage of Amplitude modulation is decreased from 100% to 50% then the power in the sidebands will decrease by _____.

8. In a MOPA transmitter, any changes in antenna loading would not be reflected back to the oscillator circuit because of the _____.

9. It is quite common to use a _____ as a dummy antenna for testing of low power transmitters.

10. It is undesirable to have a transmitter connected to an antenna while it is being adjusted because of the possibility of radiating _____.

11. A Faraday shield may be installed between the final tank coil and the antenna coil for the purpose of reducing _____ coupling between the output tank and antenna.

12. When the frequency of a crystal increases with temperature it is said to have a _____ temperature coefficient.

13. Lead inductances and stray capacities are often responsible for _____ oscillations in an RF amplifier.

14. A tapped tank coil is the key to identifying a _____ oscillator.

15. A split tank capacitor identifies the _____type oscillator.

16. An RF choke should offer low opposition to the flow of _____.

17. A transistor or vacuum tube which is biased so that current flows for one half of the alternating current cycle is operating class _____.

18. A class C amplifier is not suitable for _____.

19. An audio amplifier is supplying 30 volts RMS to a 500 ohm load. What is the average power supplied. _____

20. An amplifier in which the resting current is the same as the signal current is operating in Class _____.

21. A vacuum tube having amplification factor of 20 and operating with 2000 volts on its plate should have _____ volts applied to its grid to bias it to cutoff.

22. A resistor connected across the output of a power supply for the purpose of improving regulation is called a _____.

23. An inductor whose inductance decreases with increased current is called a _____ _____ when used as a part of the power supply filter.

24. A power supply delivers 250 volts under load, but increases to 300 volts when the load is removed. Its percentage of regulation is _____.

25. A series ac circuit has 12 ohms of resistance and 20 ohms of capacitance reactance. Its impedance would be _____.

26. A series resonant circuit has a Q of 25. Its bandpass would be _____ at 1000 KHz.

27. A series resonant circuit consists of a 1 mh. inductance and a 1000 pf. capacitance. What is its resonant frequency _____.

28. There will be _____ amperes flowing to a circuit consisting of a resistance of 10 ohms, and inductive reactance of 5 ohms and a capacitive reactance of 7 ohms all connected in parallel to a 100 volt ac source.

29. A series ac circuit has a 20 ohm resistance, a 45 ohm inductive reactance and a 30 ohm capacitive reactance connected to a 100 volt source. There will be _____ amperes through the inductance.

30. Interlaced scanning is used in the television system to _____ _____.

31. The output of a TV transmitter is _____ modulated.

32. A diplexer is used with the TV transmitter for the purpose of allowing the _____ _____ & _____ _____ to be connected to a single antenna.

33. The sound transmitter of a TV station is _____ modulated.

34. The colorburst signal is used for the purpose of _____ the receiver _____ _____.

35. A radio receiver whose IF is 465 KHz and tuned to 1000 KHz would have an image frequency response at _____ KHz.

36. The first detector in a superheterodyne receiver is also called a _____.

37. A ratio detector has greater immunity to amplitude modulation and noise than does a _____ type of FM detector.

38. Preemphasis is used in an FM transmitter so that the high frequencies will be _____.

39. A superheterodyne receiver using a low IF frequency will have poor _____ _____.

40. A diode detector is used for demodulation of _____ type modulation.

41. If the antenna current at a broadcast station is 10 amperes for 5 KW, then what antenna current will exist if the power is increased to 10 KW. _____

42. The radio wave has a _____ field and a _____ field.

43. The wavelength of a 1000 KHz broadcast station would be _____.

44. A marconi antenna for a broadcast station operating at 1000 KHz would be _____ _____ long.

45. A marconi antenna must have a _____ if the soil resistance is high.

46. A TV antenna normally has _____ polarization.

47. The characteristic impedance of a transmission line is the impedance of a line which is _____ long.

48. Radio waves propagate with a velocity of _____ meters/sec.

49. The velocity of radio waves is _____ in a transmission line than in free space.

50. A 2 meter marconi antenna would be _____ long.

51. A one half wavelength antenna for the FM broadcast band would be approximately _____ long.

52. Two towers of a 950 KHz directional antenna are separated by 120 electrical degrees. Their separation in feet is approximately _____.

53. Fading is caused by the skywave being out of _____ with the ground wave.

54. A transmission line should normally be terminated in its_____ _____.

55. The FM broadcast channel is _____ KHz wide.

56. The TV aural channel plus the TV video are allocated a bandwidth of _____ mHz.

57. A carbon microphone converts sound waves into _____.

58. A dynamic microphone converts sound waves into _____.

59. Single sideband reception requires _____ reinsertion at the receiver.

60. Single sideband type transmission is not used in the AM braodcast band because of the necessity to provide _____ at every receiver.

61. High gain antennas are often used at FM stations in order to _____.

62. It is impractical to have a high gain antenna operating in the AM broadcast band because of _____ _____.

63. A resistance-capacitance phase shift oscillator requires a minimum of _____ RC phase shift sections.

64. The mutual inductance of two coils having coupling coefficient of one is _____ if one coil is 2 H and the other is 8 H.

65. A transformer designed to match an 8 ohm voice coil to a 7200 ohm amplifier circuit will have a turns ratio of _____.

66. A 5 mh. RF choke has a reactance of _____ at 1000 KHz.

67. Two coils of .2 and .8 Henry have a mutual of .1 Henry. Therefore the coefficient of coupling must be _____.

68. Two capacitors of 3 MF and 6 MF are connected in series to produce a resultant capacity of _____ MF.

69. A 1000 MF. capacitor in series with a 1 megohm resistor has a time constant of _____ seconds.

70. A megawatt transmitter has a _____dB output level with respect to one KW.

71. An inductance of 8 mH and one of 6 mH in parallel have an equivalent inductance of _____.

72. A radian is equal to _____degrees.

73. There are _____ degrees in an alternating current cycle.

74. A Hertz antenna is _____ long.

75. An Armstrong oscillator makes use of a _____ coil.

I. KEY TO PROGRESS TESTS AND FINAL EXAM

Test No. 1	1	b	6	b	11	d	16	c	20	d	25	c	30	c
	2	a	7	a	12	a	17	a	21	c	26	b	31	d
	3	a	8	a	13	c	18	b	22	d	27	b	32	a
	4	b	9	c	14	c	19	c	23	d	28	d	33	a
	5	b	10	d	15	c	20	d	24	a	29	a	34	c
													35	b
	36	a	41	a	46	b	51	a	57	a	63	a	69	c
	37	a	42	d	47	c	52	c	58	b	64	c	70	d
	38	c	43	b	48	b	53	d	59	b	65	b		
	39	b	44	c	49	a	54	b	60	c	66	a		
	40	d	45	c	50	c	55	b	61	b	67	b		
							56	a	62	b	68	b		
Test No. 2	1	d	6	c	12	a	18	d	24	b	30	a	36	c
	2	b	7	c	13	d	19	b	25	c	31	b	37	d
	3	c	8	d	14	c	20	d	26	d	32	d	38	b
	4	a	9	d	15	c	21	a-d	27	d	33	c	39	c
	5	d	10	c	16	b	22	c	28	b	34	d	40	b
			11	a	17	a	23	c	29	a	35	e	41	c
	42	a	48	e	54	a								
	43	b	49	a	55	c								
	44	d	50	a	56	a								
	45	c	51	c	57	c								
	46	d	52	c	58	e								
	47	b	53	d	59	a								
Test No. 3	1	a	6	d	12	c	18	b	24	b	30	c	36	a
	2	c	7	a	13	b	19	d	25	a	31	b	37	c
	3	c	8	a	14	c	20	d	26	a	32	d	38	d
	4	b	9	a	15	c	21	b	27	d	33	c	39	c
	5	d	10	d	16	a	22	b	28	c	34	c	40	b
			11	c	17	c	23	b	29	c	35	c	41	a
	42	b	47	c	52	a	57	b	63	a	69	a		
	43	a	48	c	53	b	58	a	64	c	70	c		
	44	b	49	c	54	a	59	a	65	b				
	45	d	50	b	55	b	60	a	66	a				
	46	b	51	a	56	d	61	a	67	b				
							62	d	68	b				

KEY TO FINAL EXAM

1. Neutralize
2. Remove Power (Supply)
3. 800 Hz
4. 22.5%
5. 50%
6. 1100 KHz and 900 KHz
7. 77%
8. Buffer
9. Lamp bulb
10. Interfering signals
11. Capacitive
12. Positive
13. Parasitic
14. Hartley
15. Colpitts
16. Direct Current
17. B
18. Audio
19. 1.8 Watts
20. A
21. -100
22. Bleeder
23. Swinging Choke
24. 20%
25. 23.3
26. 40 KHz
27. 159 KHz
28. 11.5 amp
29. 4 amp
30. Reduce Flicker
31. Amplitude
32. Sound Transmitter and Picture Transmitter
33. Frequency
34. Synchronizing the 3.58 mc (color) oscillator
35. 1930 KHz
36. Mixer
37. Foster Seeley
38. Accentuated
39. Image Rejection
40. Amplitude
41. 14.14 amps
42. Electric and Magnetic
43. 300 Meters
44. 75 Meters
45. Counterpoise
46. Horizontal
47. Infinitely
48. 300,000,000
49. Less
50. 1.2 Meter
51. 1.5 Meter
52. 115 ft
53. Phase
54. Characteristic
55. 200
56. 6
57. Resistance variations
58. Voltage variations
59. Carrier
60 Carrier reinsertion
61. Increase range
62. Physical size
63. 3
64. 4 H_1
65. 30:1
66. 31400Ω
67. .25
68. 2 MF
69. 10^3
70 30

96

V. RECOMMENDATIONS

Electronic Communications I, as a part of the Electronics Engineering Technology program, was presented for the first time during term II of the 1974-1975 academic year. The developed material may be considered a reality - useable for future offerings. As a result of the course development and initial experience there are several comments and recommendations that are appropriate. Improvements are always possible and this instance is no exception. There are at least two areas of potential weakness:

1. Textbook: A number of texts directed to the subject and of recent origin, are now offered by the various publishers. Of the eight texts reviewed, none can be considered satisfactory. They range from being poorly written, obsolete or even in error, to those better written but poorly adapted to integration into an overall technology program. The text selected was considered as least undesireable of the available choices. Its primary advantage is that it is oriented toward the Federal Communications Commission Commercial License examination and may serve the student as a reference when he chooses to pursue this objective. Problems were partially overcome thru use of the instructors supplementary notes (see appendix) but this method is not completely satisfactory.

   It is therefore recommended that this text be considered as a candidate for replacement. It is probable that a major publisher may recognize the need and that a more satisfactory text will become available. Instructors and the department chairman should be alert to this possibility.

2. Laboratory equipment or training devices: The experiments procedures as prepared were predicated upon use of readily available equipment. As such, they were satisfactory for the students registered. A high proportion of the students in this class were technically employed and were quite accustomed to improvising and substitution of less than optimum components. However, there is no guarantee that future students will have any technical orientation other than secured from the program itself. Therefore, specially prepared, commercially available training equipment is recommended for purchase when funds are available. A description of the recommended equipment is included in the appendix to this report.

   In conjunction with the above recommendation, it may also be appropriate to consider less comprehensive material coverage than was planned for this first course. Future students may require more gradual indoctrination than was possible with the initial group. Response to this recommendation should not be implemented until a trend is established.

Other recommendations may be made relative to conduct and integration of the course. Included should be:

1. The course Electronics Communications II must soon be prepared. The second course may go into greater detail and mathematical justification than was considered appropriate for the introductory course. It is recommended that the "advanced" course be considered a problem solving course as opposed to the broad concept and vocabulary introduction already experienced. The text by Kennedy, listed in the bibliography, is tentatively considered to be a satisfactory choice.
2. Another recommendation concerns the prospect of credit by examination for those students already having considerable experience while

employed in related industry. A first and more desireable choice would be that credit be given for taking and passing the Federal Communications Commission Commercial License examination. Possession of a recently issued radio telephone 1st or 2nd class license should be considered adequate evidence of competence equivalent to that envisioned from the introductory course. A somewhat less desireable alternative would be to make use of the 3 progress tests and final examination (a part of this report). Achievement of a satisfactory score on these four tests may be considered reasonable evidence of Course I level competence.

A final recommendation reverts to the textbook deficiency already noted. A true need exists for a communications text specifically directed toward the community college level audience. Several good writers have responded to the need for 1st year course texts but so far, the 2nd year texts have been, in general, inadequate. It is recommended to this writer, and to other technology instructors, that a true opportunity and need exists. It will be some time before the need can be satisfied and, with the widespread proliferation of 4 year technology programs, the need may be compounded. It would be this writer's intention to consider of high priority an objective of writing a community college level text for Electronic Communications.

VI. REFERENCES

1. E. H. Armstrong, "A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation," Proc. IRE Vol. 24 pp 689-740 May 1936
2. J. R. Carson, "Notes on the Theory of Modulation," Proc. IEEE Vol. 51 pp 893-896 June 1963
3. A. Bruce Carlson, "Communication Systems. An Introduction to Signals and Noise," New York 1968
4. Arthur C. Clarke, The Exploration of Space, London 1951
5. Crowley, Harris, Miller, Pierce, Runyon, Modern Communications New York 1962
6. E. W. Engstrom, "Systems Engineering - A Growing Concept," Elec. Eng. 76 1957 pp 113-116
7. W. L. Everitt, G. E. Anner, Communication Engineering, New York 1956
8. Donald Fink, Television Engineering Handbook, New York 1957
9. Stanford Goldman, Frequency Analysis, Modulation and Noise, 1948
10. Arthur D. Hall, A Methodology for Systems Engineering, Princeton, N.J. 1965
11. K. Henney, Radio Engineering Handbook, New York 1959
12. Harry Hooten, Single Sideband, Theory and Practice, San Francisco 1967
13. George Krassner, Jackson Michaels, Introduction to Space Communications Systems, New York 1964
14. H. Nyquist, "Certain Factors Affecting Telegraph Speed," Bell System Tech. Journal, Vol. 3 pp 324-346 April 1924

15. M. Schwartz, W. Bennett, S. Stein, Communication Systems and Techniques, New York 1966

16. C. E. Shannon, "A Mathematical Theory of Communications," Bell System Technical Journal, Vol. 27, pp 379-423 July 1948 and Vol. 27, pp 623-656 Oct. 1948

17. F. E. Terman, Electronic and Radio Engineering, New York 1955

18. J. M. Wozencraft and I. M. Jacobs, Principles of Communication Engineering, New York 1965

B. BIBLIOGRAPHY

1. George J. Angerbauer, Electronics for Modern Communications Prentice Hall, Englewood Cliffs, N.J. 1974

2.* Clyde N. Herrick, Introduction to Electronic Communications. Merrill Publishing Co. Columbus, Ohio 1969

3.* George Kennedy, Electronic Communication Systems, McGraw Hill, New York 1970

4.* Matthew Mandl, Principles of Electronic Communications, Prentice Hall, Inc. Englewood Cliffs, N.J. 1973

5.* Gary M. Miller, Linear Circuits for Electronics Technology Prentice Hall, Englewood Cliffs, N.J. 1974.

6.* Robt. L. Shrader, Electronic Communication, McGraw Hill Oakland, Calif. 1967

7.* Morris Slurzberg and William Osterheld, Essentials of Communication Electronics, McGraw-Hill Book Co. New York 1973

8.* Lloyd Temes, Communication Electronics for Technicians, McGraw Hill Book Co. New York 1974

9. U.S. Department of Health, Education and Welfare, Office of Education Electronic Technology, A Suggested 2 year Post High School Curriculum U.S. Government Printing Office 1969

10. U.S. Department of Health, Education and Welfare, Office of Education Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs. U.S. Government Printing Office 1962

*Texts denoted were those given serious consideration for this course.